POWER PLANT ENGINEERING

Trade-mark reg. U. S. Pat. Office

VOL. XXV CHICAGO, FEBRUARY 1, 1921 No. 3

Pumping Plant of New Hunter's Point Drydock

FEATURES OF THE PUMPS, MOTORS, BUILDING AND TUNNELS FOR GRAVING DOCK CAPABLE OF ACCOMMODATING THE WORLD'S LARGEST SHIPS. BY CHARLES W. GEIGER

IN THE FOLLOWING description of the pumping plant of the immense graving dock constructed at Hunter's Point, California (immediately south of San Francisco), by the Bethlehem Shipbuilding Corporation, we have an indication of the vast stride forward in our shipping industry. Graving docks represent large outlays of money and are a necessary means for the repair of our ships. One of the most important features of a graving dock is perhaps the pumping plant. In the design of the pumping plant for the Hunter's Point dock, the engineer, Howard C. Holmes of San Francisco, has embodied all the innovations that experience has found to be desirable, and has eliminated all features that experience has found to be undesirable, thereby making this plant the last word in pumping plant construction.

Depth of the water at the side of the dock is 43 ft. below ordinary high water, and at that stage of the tide the dock proper contains 5,260,000 cu. ft., and the pump pit and sump approximately 40,000 cu. ft., or a total of 5,300,000 cu. ft., or approximately 40,000,000 gal. The capacity of the main pumps is such as to unwater the dock in 2 hr. and 15 min.

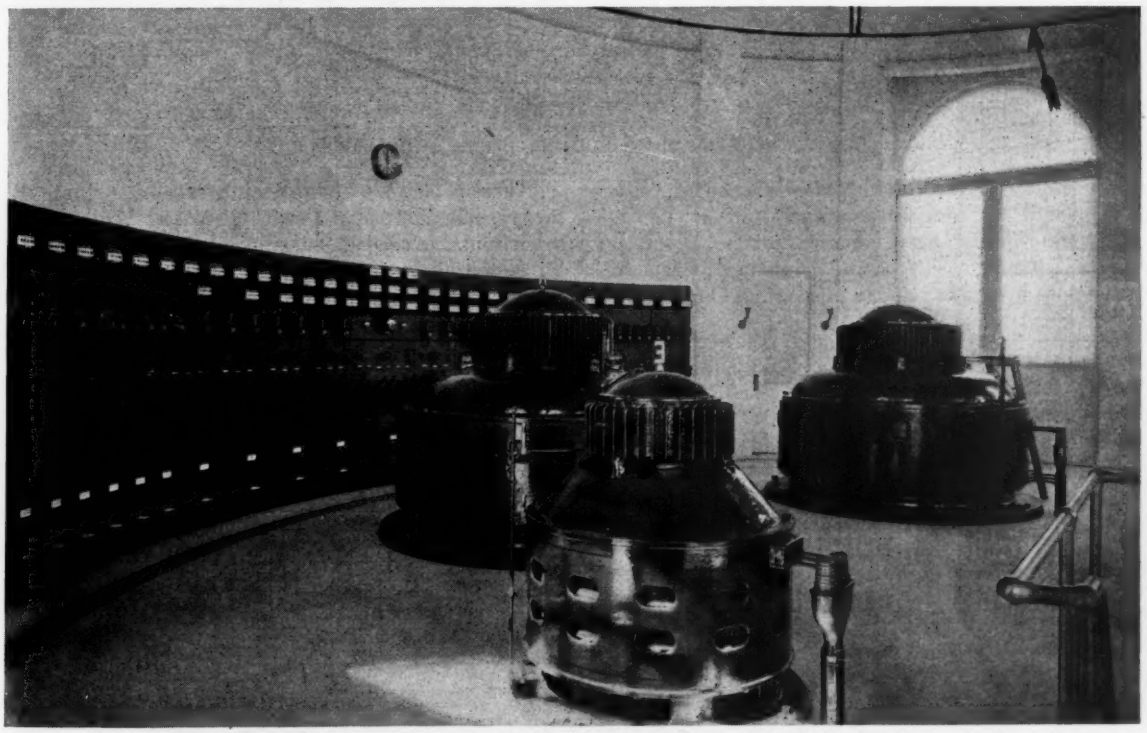


FIG. 1. INTERIOR OF PUMPING STATION SHOWING THREE OF THE MAIN MOTORS AND MAIN SWITCHBOARD; ARROW INDICATES CIRCULAR TRACK FOR CRANE

The principal pumping plant for this purpose comprises four main pumps and two drainage pumps. All pumps are located in a sump well located on the north side of the dock. Each pump has an average capacity

of about 75,000 gal. of water per minute when pumping against a head ranging from nothing to 43 ft., running at a speed of 250 r.p.m.

Motors for driving the main and drainage pumps are of the squirrel-cage induction type, three-phase, 60 cycle. The motors for the main pumps are 750 hp. each. The motors are rated at 2200 v. delivering their full rated capacity under any collective total variation of voltage and frequency not over 10 per cent.

The motors are rugged, simple, and fool-proof construction, with all electrical and mechanical parts constructed with a view to reliable, efficient and noiselessness of operation throughout the range of voltage given above. The main pumps will start with the discharge valves closed; the motors having ample starting torque for this condition, having been so designed with their starting apparatus that the starting current will not exceed twice the normal full-load current of the motors.

Each of the two drainage pumps consists of a vertical shaft, single bottom suction, single impeller, volute centrifugal pump direct-connected to a constant speed, alternating current, vertical shaft motor of 110 hp. Each pump has 15-in. bottom suction, and an average capacity of 5000 gal. per min. pumping against a head varying from 43 to 62 ft., at 600 r.p.m.

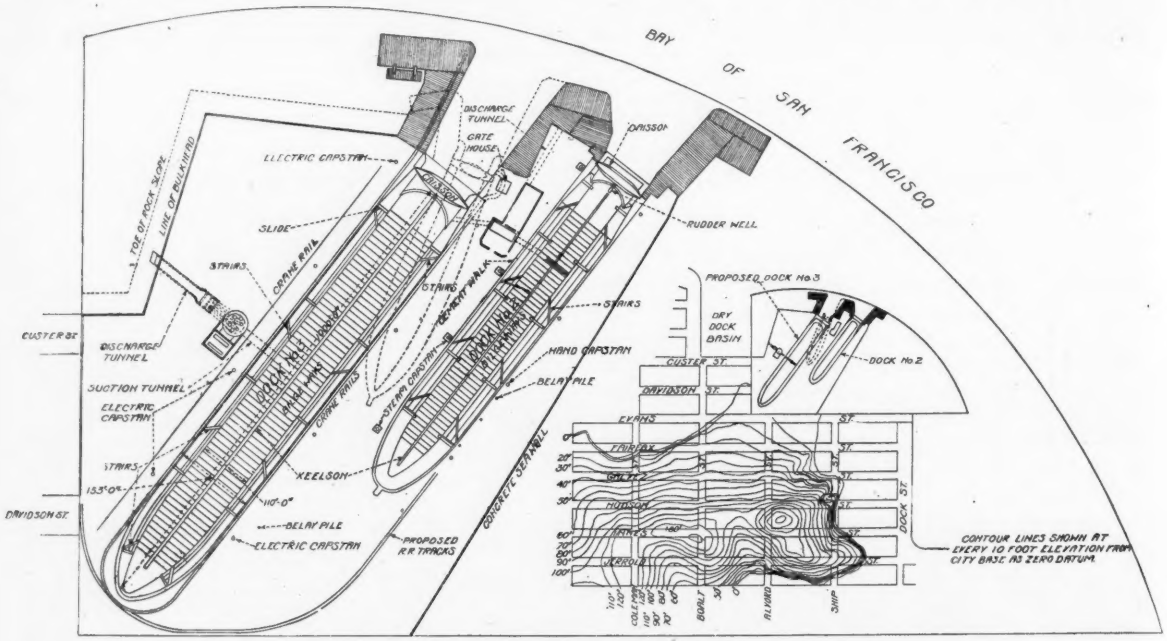


FIG. 2. GENERAL PLAN SHOWING LOCATION OF DRYDOCK

There is also one high-pressure, salt-water pump used for washing down and testing purposes. This pump is a horizontal, two-stage turbine pump coupled to a 100-hp. motor, all mounted on cast-iron base, suction and discharge being respectively 8 in. and 6 in. in diameter. The capacity of this pump is 1200 g.p.m. against a pressure of 100 lb. per sq. in. when running at 1800 r.p.m. Under these conditions 65 per cent efficiency is obtained.

The suction pipes to the main pumps are of cast iron, 54 in. in diameter with bell mouth at the bottom and flange for connection at the top. Circumferential ribs

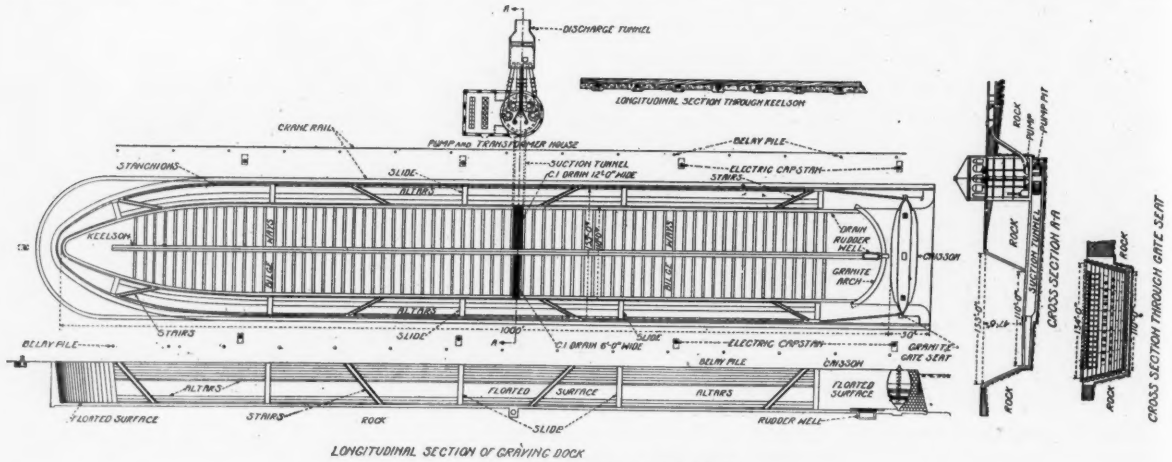


FIG. 3. GENERAL PLAN OF DOCK

cast on the outside of the pipes for proper anchoring in the concrete, the ends of the suction pipes coming within 2 ft. of the floor of the suction chamber.

Pump casings are of close grained cast iron, 1¼ in. thick. They are of volute form, made in sections with vertical and horizontal joints to facilitate removal through openings left in the floor of the motor room. The pedestals were cast integral for securing to the concrete foundation. The casing and adjacent parts were so designed and constructed that the impeller may be removed from the casing without breaking joints on the pipe or separating parts of the casing.

Casings are provided with suitable bushings to effect a close running fit with the impellers. The bushings are of non-corrosive material and of detail to insure accurate erection and easy removal.

arrangement is just the opposite, the electric motor driving the pump. The success of this bearing has surpassed the expectation of Mr. Holmes, running cool at all times and requiring no auxiliaries for cooling purposes such as cooling water, forced lubrication, etc. The bearings are self-alining and self-adjusting. In the cap that covers the bearing there is a small opening with a hinged top that permits the man in charge to examine the bearing. All shafts are forged from open hearth steel and of ample strength to resist all tension and bending and direct forces to which they could possibly be subjected. Adjacent lengths are connected together in such a manner as to transmit all stresses and permit care and accuracy of erection and removal of any length.

Motors for driving the main and drainage pumps were designed to be used on intermittent service. On

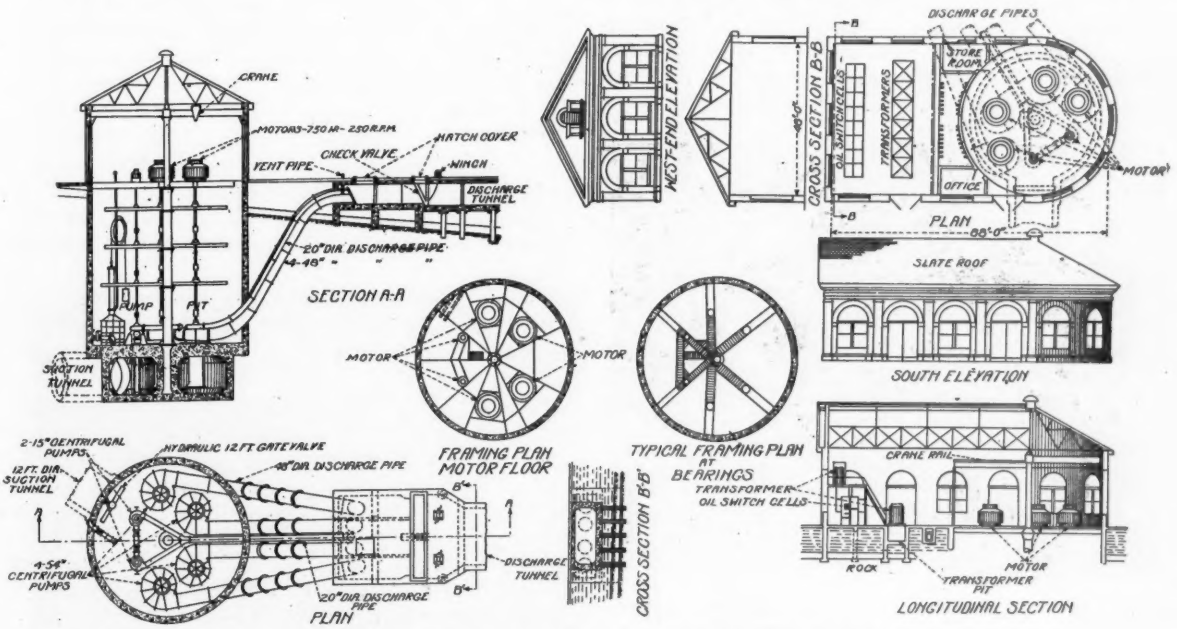


FIG. 4. GENERAL PLAN OF PUMP AND TRANSFORMER HOUSE

Before shipment from the manufacturer, each casing, including the top head, was subjected to 50 lb. water pressure the square inch for at least 5 min. without sweating or leakage. The pump bearings are external to the casing and separate from the stuffing box, which is located between the bearing and the pump. Removable parts, stuffing box, including gland and studs, are of non-corrosive metal. The impeller is of close-grained cast iron, firmly secured to the shaft and held in place by a nut on the lower end.

All revolving parts of each pumping unit are carried on one thrust bearing liberally designed to carry the weight of all rotating parts in addition to the hydraulic thrust. The bearings are located at the top of the motors where they are readily accessible. In Fig. 1 the letters A and E show the cap that encloses this bearing. This cap can be removed to give ready access to the bearings. This is a modification of the Kingsbury bearings, and it is believed to be the first time that such a bearing has been used in a plant of this kind. Kingsbury bearings have previously been used in hydroelectric plants, where the turbine drives a generator, but in this case the

account of the conditions of temperature and humidity, the manufacturer used particular care in the selection of the materials and their application, so as to provide a high-grade insulation that would meet the conditions of service and climate in a satisfactory manner. The insulation was required to withstand the usual breakdown tests, as specified in the latest Standardization Rules of the American Institute of Electrical Engineers, and the insulation resistance of the temperature corresponding to the operating temperature after 2 hr. run at rated full load was required to equal or exceed the values specified in those rules.

Each of the main pumping units are capable of pumping out the drydock alone in a period of approximately 9 hr., and the motors are rated accordingly and were so designed that after 9 hr. run at 2200 v. at motor terminals and at rated full load current, the rise in temperature of the hottest spot would not exceed the value specified in the latest Standardization Rules of the American Institute of Electrical Engineers for Class A-1 insulation. The temperature of the hottest spot was determined by the embedded temperature-detector

method, the detector being installed and the correction factor applied in the manner specified in the Standardization Rules above referred to. The temperatures of the bearings and of the squirrel-cage armatures were determined by the thermometer method.

The drainage pumping units were required to be capable of continuous operation at the maximum load that would occur under the normal range of head previously specified. The drainage-pump motors are rated accordingly, and were so designed that after continuous operation at 2200 v. at the rated full-load current until such times as the temperature of electrical circuits, squirrel-cage armatures and bearings shall have become constant, the temperature rise would not exceed that specified for the 9 hr. run on the main-pump motors.

The pump and transformer house is of concrete, the walls being 1 ft. in thickness of this material, the inside being plastered by means of a cement gun, and the exterior walls veneered with what is known as stock brick, which corresponds in color and size to those in the existing pumping station for dock No. 2. This veneer is 4 in.

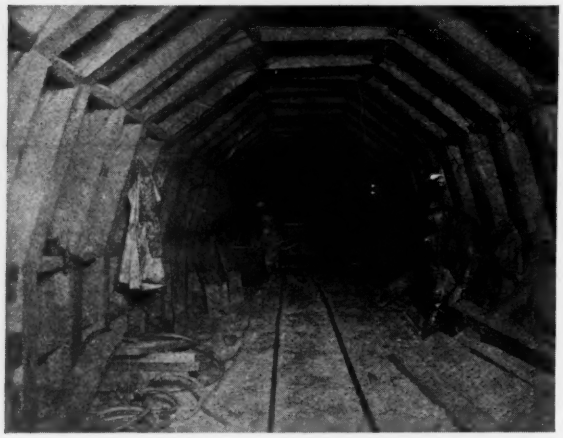


FIG. 5. VIEW IN TUNNEL DURING CONSTRUCTION. PHOTOGRAPH BY LOTHERS & YOUNG

thick, the concrete in the main walls having wire anchorage for the veneer, approximating one to every 4 sq. ft.

Features of Pump-House Construction

The whole of the interior of the pump and transformer house is plastered by means of a cement gun with a coat ⅜ in. thick, the plaster consisting of equal parts of cement and sand, all trowled to a smooth finish, the walls having cornice inside, at the height of the partition, of 6 by 12 in., formed with concrete. White cement and white sand were used to plaster the walls which makes a very pleasing finish. The building is 98 ft. in length and 48 ft. in width, the pump house being circular, having a diameter of 48 ft.

Roof trusses are of structural steel having a 48-ft. span. The roof is covered with cinder concrete 4 in. in thickness, consisting of one part cement, two parts sand and four parts cinders, and is reinforced with welded metallic fabric mesh 3 by 8 in. No. 8 and 10 gage, bedded in concrete every 2 ft. centers. Nailing strips of 1 by 2 in. Oregon pine are laid parallel with the rafters.

The roof is covered with slates 12 by 24 in. dimensions. All slates are laid one-third over first, secured with 1¼-in. copper slate nails, two to each slate. Slates are fastened to nailing battens, which in turn are fastened to nailing strips embedded in the roof, canted ⅜ in. at the eaves so that the courses will lie tight, and also doubled at ridges.

Floors in the transformer room are of concrete, main body of the floor being 6 in. thick, and covered with 1-in. hexagonal white ceramic tile. There is also a platform in the pump room 24 by 6 ft. wide, with tiled floor and 6-in. border.

There is a circular partition 6 in. thick, between the transformer and pump rooms of reinforced concrete, with metallic fabric extending to the height of the track for a traveling crane. This crane has a capacity of 25 tons. There is a cast-iron column that extends from the bottom of the circular pump pit to the roof. This is shown in section A-A in the general plan of the pump house, Fig. 4. The crane is pivoted to the column at a height of 24 ft. above the floor of the pump house, and travels in a circle, the outer end of the crane traveling on the track that is supported by the circular wall of the pump house. By this means, any piece of machinery in the pump house can be picked up and delivered to the main door of the pump house, or vice versa. The circular track on the outer wall can be seen at the arrow represented in Fig. 1, and in section A-A in the plans, Fig. 4.

Connecting the dock with the pump pit is a tunnel, Fig. 5, 12 ft. inside diameter, constructed of reinforced concrete, shown in cross-section A-A, Fig. 3, of the plans. The walls of this tunnel are 24 in. thick built into the solid rock. There is a cast-iron drain over the suction tunnel, in the bottom of the dock, one section of the drain being 12 ft. wide and the other section being 6 ft. wide, this being shown in the plans, Fig. 3. There is a gate valve, 12 ft. in diameter, and a bypass valve leading from the 12-ft. tunnel to the pump pit, to relieve pressure against the gate valve. The sumps are connected together with a tunnel, and are coated on the inside with asphalt. The floors of the sumps are 2 ft. in thickness, heavily reinforced. The walls of the sumps are 12 ft. in height and 2 ft. in thickness. The floor of the pump pit is 4 ft. thick and extra heavily reinforced to withstand the terrific upward pressure of the water in the sump. All this concrete work is built in solid rock.

The floor of the pump pit is 51 ft. 6 in. below the floor of the pump room. The floor beams of the pump room are 24-in. beams 72 lb. to the foot and have plates 12 by 12½ in. thick on the wall; 12-in. beams are used on the three floors below the pump-room floor, all beams being supported in the center of the pit by the cast-iron column that extends from the bottom of the pit to the roof.

Metal stairways lead from the floor of the pump room to the floor of the pump pit, having 2-in. gas pipe railing and checkered treads and open risers.

A very novel system has been employed in ventilating the sumps. It often happens that fuel oil is discharged in the dock, and this eventually is drained into the sumps. This is likely to generate gas within the sumps, which would be dangerous if an open blaze should come in contact with it. In order to eliminate this danger, a number of openings extend from the sumps to the cast-

iron column which is hollow. An electrically operated suction fan is placed in the roof truss, which draws air up from the sump through the cast-iron column, and discharges it through a louver in the roof, thus any gas that might accumulate in the sumps is drawn out, and discharged into the air. This precaution was taken because gas accumulated in the sumps of the pumping plant of dock No. 2 and was ignited when an employe entered the sump with a torch.

Discharge piping from the main pumps are 48 in. in diameter, all of cast iron embedded in concrete. Each pipe has cast-iron check valves with bronze seats at the end. The discharge pipe for the drainage pumps is connected to both pumps and is 20 in. inside diameter, with a check valve at the mouth. The main discharge pipes of the drainage pumps have connections with both the San Francisco high-pressure salt water and Spring Valley water mains, with gate valve in each, for the purpose of priming the drainage pumps. There are check valves at the entrance to the discharge culvert. They are of cast iron, rectangular, 8 by 11 ft., with bronze seat and liner. Two man winches are provided for raising these check valves.

The discharge tunnel is rectangular in form and is supported upon a pile foundation. The top of the discharge tunnel is covered with 2 in. of asphalt. Cast-iron

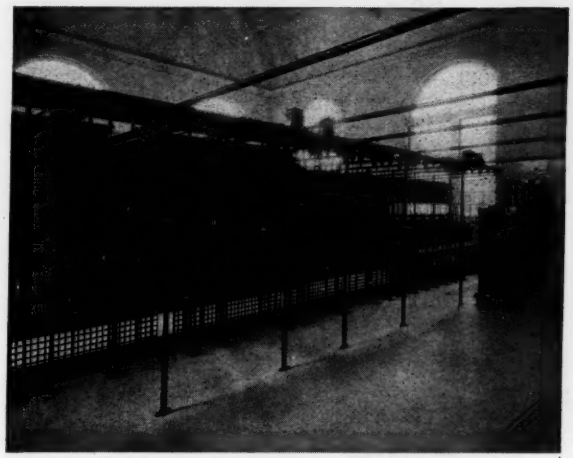


FIG. 6. INTERIOR OF TRANSFORMER ROOM

hatch covers give access to the cast-iron check valves at the end of the 48-in. discharge pipes.

SOURCE OF POWER

POWER IS furnished at 11,000 v., three-phase, 60 cycles, from the system of the Pacific Gas & Electric Co., over a 4/0 overhead line, terminating at the property limit of the Union Iron Works Drydock Co., where two pole-top switches operated from the ground controls duplicate underground cables, feeding the Drydock Co.'s substation to the north of the new graving dock about 650 ft. distant.

The power company has installed in the Drydock Co.'s substation all the necessary high-tension bus compartments, oil switches, wiring and transformers for the simultaneous operation of the following equipment, for a period of 2 hr.:

Four 750-hp., three 250-hp., three 100-hp., 2200-v., 3-phase motors.

Two 100-hp., two 75-hp., 440-v., 3-phase motors.

100-kv.a. in lighting and portable motors at 208 v., 3-phase, 4-wire.

The two 250-hp. motors are for use in connection with drydock No. 2.

The power company connected up the stars, on the low-tension side of all transformer banks, from which point all wiring and connections were furnished and installed by the Drydock Co.

All power is measured on the low-tension side of the transformers. The meters for this purpose were furnished and installed by the Drydock Co., subject to periodical inspection and test by the power company.

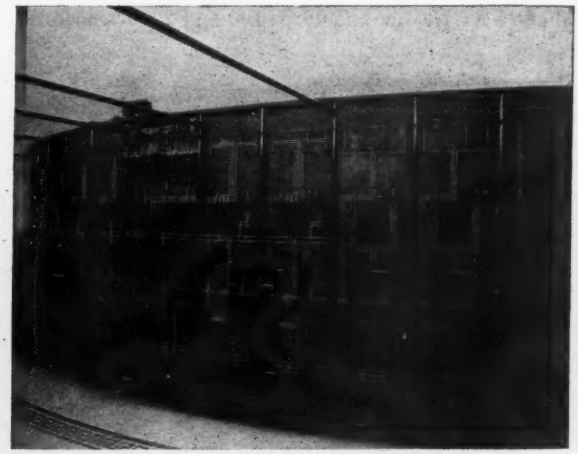


FIG. 7. REAR VIEW OF CIRCULAR SWITCHBOARD

The Union Iron Works Drydock Co. furnished and installed in its switchboard a 32 by 90-in. slate panel for the reception of the oil switch control levers, and such metering equipment as the power company saw fit to install.

DISTRIBUTION SYSTEM

POWER IS distributed from the substation at the following voltages:

Main pumping station motors—2400 v., 3-phase.

Caisson pumps, cranes, capstans, etc.—480 v., 3-phase.

Lighting—208 v., 3-phase, 4-wire, with grounded neutral giving 120 v. at lamps.

All feeder circuits are carried underground by means of 3-conductor, lead-covered, paper-insulated cable, installed in vitrified tile ducts with fiber laterals and reinforced concrete manholes.

All 2400-v. feeder cables are 250,000 c.m. 3-conductor, insulated with 3/32 plus 3/32 saturated paper and covered with a 1/8-in. lead sheath.

All 480 and 208-v. cables and 4/0, 3-conductor, insulated with 2/32 plus 2/32 saturated paper and covered with 1/8-in. lead sheath.

The neutral wire of the lighting system is a 4/0 stranded weather-proof wire.

4/0 lead cable is run and connection boxes for ship-lighting cables, blowers and capstans installed at convenient points along the dock.

All conduits from substation to manholes, and between manholes, is of 3½-in. 3-duct, vitrified tile, stacked vertically to give the required number of ducts, and laid with all joints staggered and doweled, and covered with one layer of burlap dipped in hot asphaltum.

The entire duct line is surrounded by a 3-in. concrete envelope, but the concrete between layers of ducts are omitted to give flexibility to the lines.

All conduit laterals between manholes, handholes and distribution boxes are of 3½-in. socket joint fiber.

For starting the 2200-v. motors in the main pumping station, a 3-phase type starting compensator, with 66⅔ per cent, 75 per cent and 90 per cent taps has been installed.

This compensator was designed to withstand full line voltage for a period of 30 min., and during this period to start six 750-hp. and three 100-hp., 2200-v. motors.

transformer station, pumping station, dock-master's residence and both caissons.

Lighting of the entire property is by means of 110-v. nitrogen filled 1000-watt lamps for outside illumination, and 110-v. tungsten lamps for inside illumination.

A novel feature of the electrical installation is the switchboard shown in Figs. 1 and 7, this being made of slate, semi-circular in form.

Waste of Cedar Wood

By J. B. Dillon

CIGAR manufacturers, according to statistics, spend $55,000,000 yearly for cigar boxes, which under the present law, must not be used for cigars again. There are billions of boxes made, a small percentage, after being emptied of cigars, being used as "hell-boxes"

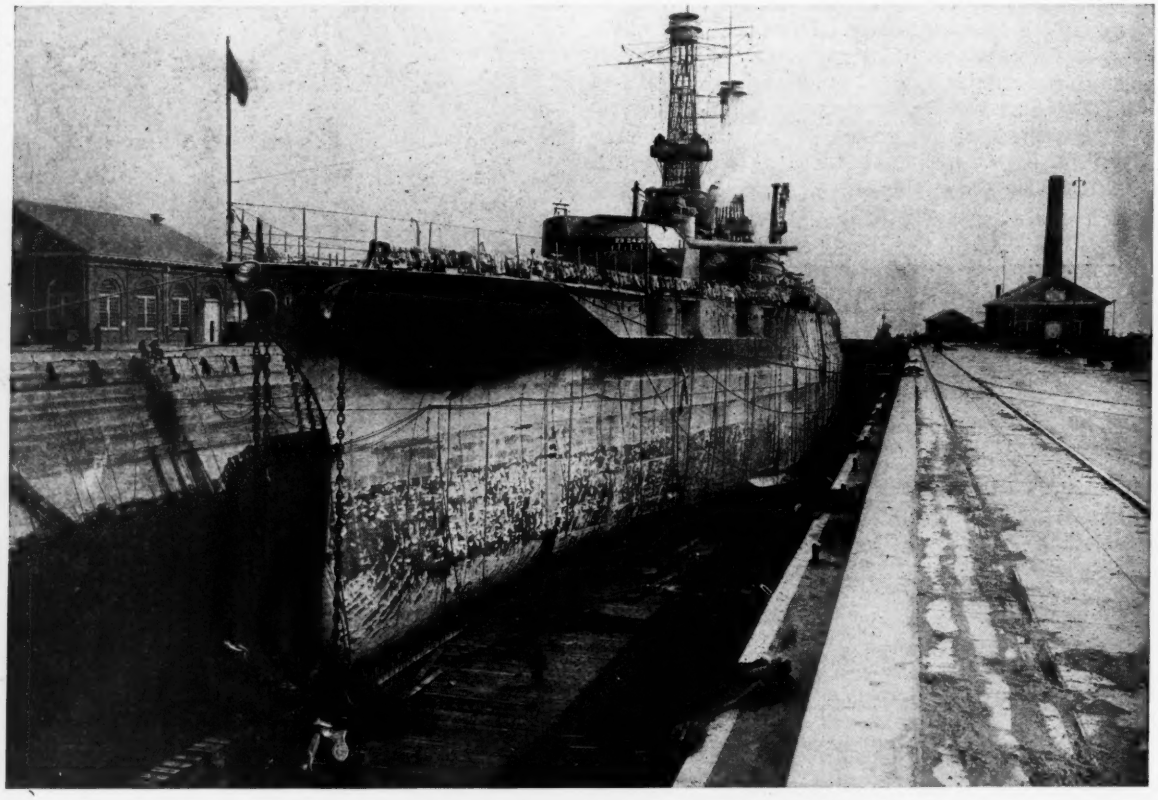


FIG. 8. THE MISSISSIPPI IN HUNTER'S POINT DRYDOCK

No switch gear is required for this compensator, owing to the use of double-throw oil switches on each motor panel.

All 440-v. motors above 7½ hp. rating are equipped with starting compensators, having no voltage release, over-load relays for running protection, and cartridge fuse panels for starting protection.

All interior wiring to lamps, motors, etc., is composed of double braid stranded, rubber-covered 1911 Code wire, installed in duct, hot galvanized iron conduit, laid in the forms before pouring concrete.

A complete inter-communicating telephone system, with wires laid in underground conduit, connects the dock-master's station at the head of the dock with the

by some mechanics and the remainder used as fuel. Cedar wood for fuel! Think of it!

As is well known, cedar makes the only practical wood encasement for lead pencils, clothing chests as a preventive against moths, and is without doubt the best wood for telegraph poles.

Small wonder that the price is exorbitant!

To go into all of the ramifications concerning the law as regarding cigar boxes, and amendment thereto, substitutes, etc., would make an article too long and would be outside the realm of power plants, but the matter is thus briefly presented with the hope that readers will deny the flames this wood and return it to the market in usable condition, thereby reducing our wanton destruction, and doing the world a favor.

Long Distance High-Pressure Steam Line

NEW 175-LB. LONG DISTANCE STEAM LINE SUPPLIES TWO DAYTON FACTORIES WITH POWER AND HEAT

WHEN TWO large factories operated by the General Motors Co., one the Dayton Engineering Laboratories Co., and the other the Delco Light Co. were built at Dayton, Ohio, they were each equipped with steam generating plants for power and heating purposes and for process work. This arrangement proved satisfactory and the individual steam generating plants served the entire needs of the factories.

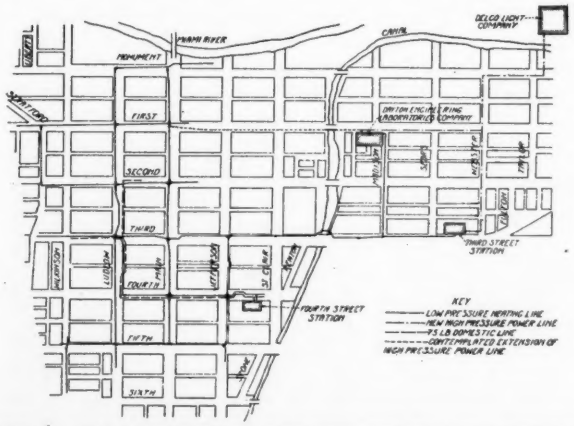


FIG. 1. MAP SHOWING OLD LOW-PRESSURE HEATING SYSTEM AND RELATIVE LOCATION OF NEW HIGH-PRESSURE LINE

During the winter of 1919-1920, however, during a period when the coal shortage throughout the country became acute, these two plants found themselves without coal and as a consequence were badly crippled. Furthermore, several new additions to the factories had so increased the demand for steam that the steam generating plants (when coal could be secured) were severely taxed.

Rather than install additional boiler capacity to take care of the increased load, it was decided at this time to insure, not only an ample supply of steam for present as well as future expansion of the factories, but also to insure against the effects of any such coal shortage as existed at that time.

This, it was determined, would be accomplished by shutting down their own steam plants and purchasing the entire supply from the Dayton Power and Light Co., which, being a public service company, could obtain coal when an isolated plant could not.

Supplying high-pressure steam to two large factories, each over a half mile from the power plant, was obviously not such a simple proposition as it would have been if the power so transmitted had been electrical. The Dayton Power and Light Co., however, had long operated an extensive low-pressure central heating system, supplying the business district of Dayton with steam for both heating and domestic purposes in hotels, restaurants, etc. The engineers of this company were, therefore, well versed in problems of steam transmission over long distances and attacked the problem with full confidence in its ultimate success. Since the low-pressure heating system referred to above will ultimately connect and is at the present time used in conjunction with the new high-pressure steam line, a few words of description of the old system will not be out of place.

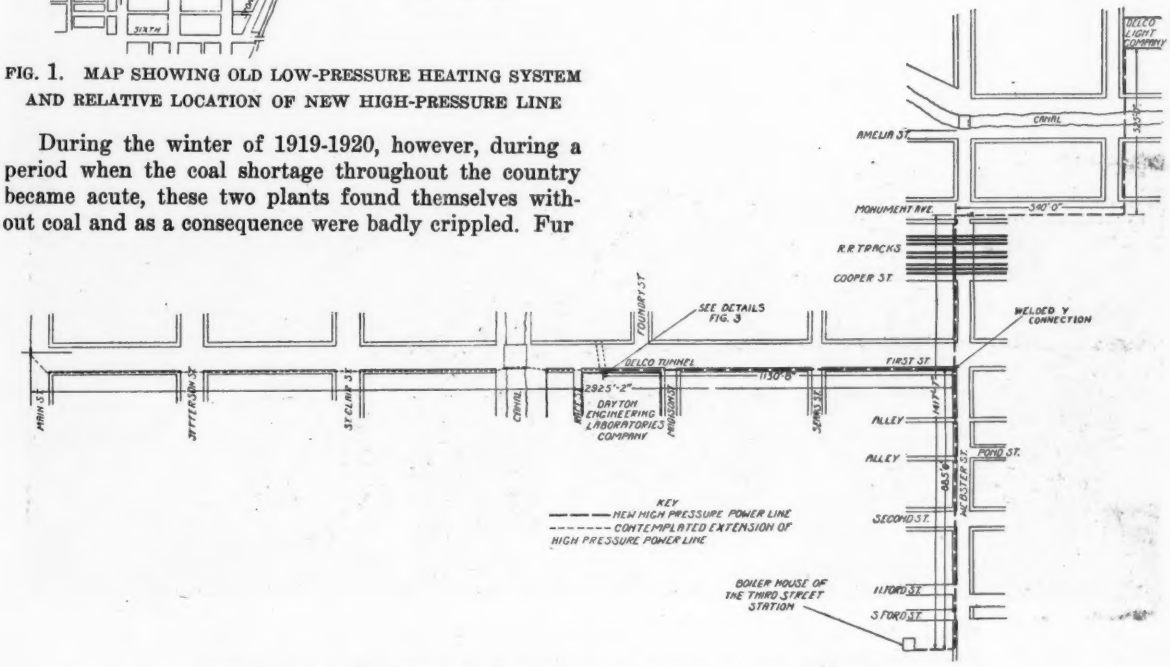


FIG. 2. MAP SHOWING ROUTE FOLLOWED BY THE NEW 175-LB. STEAM LINE

As may be seen by referring to Fig. 1, this low-pressure system is supplied from two sources, the Third Street station and the Fourth Street station, of the Dayton Power and Light Co. There are, in fact, two systems; one a low-pressure steam heating system, operating at about 1 to 5 lb. pressure and connected to 850,000 sq. ft. of equivalent direct radiation, and the other, a high-pressure system, operating at 75 lb. supplying steam for cooking purposes to hotels and restaurants. The latter line is served only from the Fourth Street

station, while the low-pressure heating system is fed from both stations. The demand on the 75-lb. line is approximately 15,000 lb. of steam per hour, while the approximate daily maximum demand in zero weather has been about 265,000 lb.

These are both one-pipe systems and no effort is made to return or make use of the condensate. Heat is delivered to customers and sold at a definite rate, all consumption being measured by condensation meters.

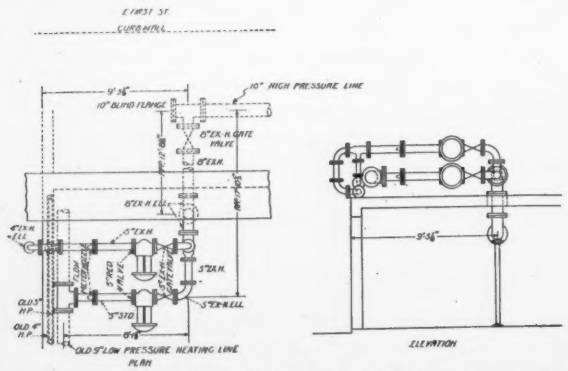


FIG. 3. DETAILS OF ENTRANCE CONNECTIONS AT THE DAYTON ENGINEERING LABORATORIES CO.

This heating system serves practically every office building, hotel and store in the business portion of the city. At the Fourth Street station exhaust steam from a tandem compound engine is sent into the system, while at Third Street steam is bled from the intermediate stages of a 7500-kw. bleeder turbine. At both of these stations, however, provision is made for feeding live steam into the lines when the load becomes heavy.

The New High-Pressure Line

The new high-pressure line which has recently been put in operation differs radically, both in construction and size, from the system described in the foregoing. This line, carrying steam at a pressure of 175 lb. per sq. in., leaves the Third Street station and follows the path shown in Fig. 2. Emerging from the station as a 14-in. line it passes through the company's premises to the west sidewalk on Webster Street and turns north, following the center line of the sidewalk. Continuing on Webster Street as a 14-in. line it runs without interruption, except for one or two small services which had to be taken off in order to secure right of way, to First Street.

At First Street, the line divides, a 10-in. line going west on First Street and a 12-in. line continuing north on Webster Street, passing under the railroad tracks shown at a depth of 8 ft. At Monument Avenue, at a point over 1600 ft. from the power station, the line takes an eastward course and follows this street to Taylor Street where it again turns northward, and after crossing a small canal finally enters the premises of the Delco Light plant about 3000 ft. from its starting point.

Steam is used at this plant for both heating and power purposes. Reducing valves are employed both on the heating system and on the power supply line which feeds steam to engines, pumps, air compressors and apparatus for process work. All steam is measured by three condensation meters of 30,000 lb. capacity each.

At the corner of Webster and First Streets, where the line branches, the 10-in. line follows First Street west to the plant of the Dayton Engineering Laboratories Co. Details of the piping as it enters this building are shown in Fig. 3. The upper line as shown on the plan is the high-pressure line supplying steam at 130-140 lb. pressure, for power work, while the lower line connects in with the old 9-in. low-pressure heating system which enters the building on Madison Avenue, as shown in Fig. 1. This low-pressure line supplies steam at from 3 to 20 lb. pressure for heating.

It is intended, ultimately, to continue the 10-in. line westward on First Street, to Main Street, where it is proposed to connect this line in with the 12-in. low pressure heating line, through suitable reducing valves. This will then enable the low-pressure heating system to obtain steam in case of accident to points in the system.

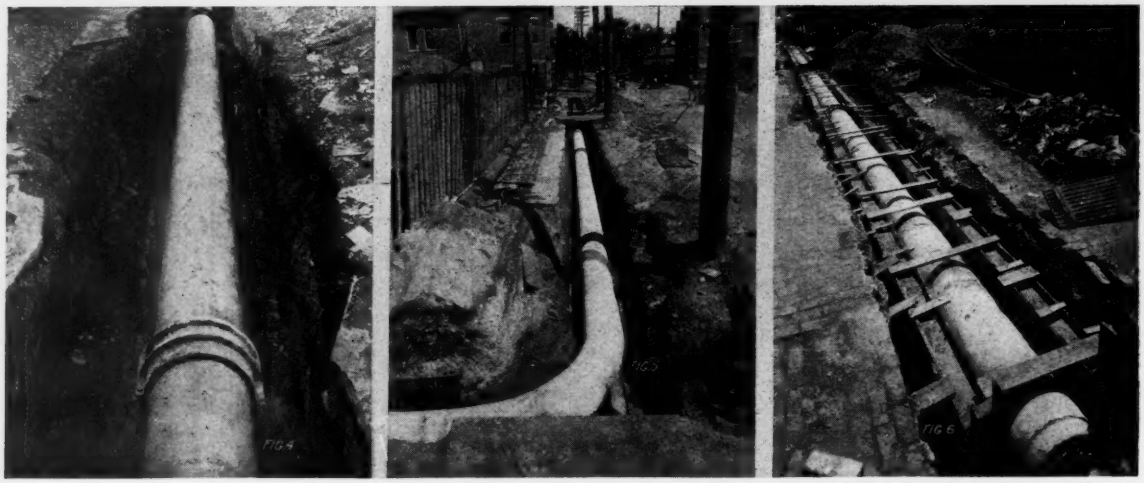


FIG. 4. PHOTOGRAPH OF COVERED PIPE SHOWING ALINEMENT GUIDES IN PLACE
FIG. 5. SHOWING LONG RADIUS BEND IN THE 14-IN. LINE LEAVING THE THIRD STREET STATION
FIG. 6. PHOTOGRAPH TAKEN DURING CONSTRUCTION OF THE SIDE WALLS OF CONCRETE DUCT

Constructional Features

The constructional features of the system are of exceptional excellence and the materials used therein are of the highest quality. Except for a short length of approximately 20 ft. where it crosses a small canal the line is entirely underground. Before actual construction began, a considerable amount of preliminary work was necessary in order to secure right of way, and, extensive alterations in existing street piping, sewers, electric power and telephone conduit, were made at the points where such piping cut the proposed route, so as to enable the new steam line to be run in the most direct manner.

The piping throughout is extra heavy wrought steel of standard dimensions. Pipe ends were bevelled to a 30 deg. angle with the longitudinal axis and all joints were electrically welded; in fact, there is not a flanged joint in the entire system.

steel, with duplex sleeves with the ends welded to the pipe line. The inner and outer sleeves are of wrought steel, the outer sleeve being nickeled and polished. Three-quarter inch, square, locomotive piston packing is used.

The entire line is enclosed in a concrete duct, the walls and top of which were built after the pipe was laid, as can be seen from the accompanying photographs. The walls are 6 in. thick reinforced with steel. To provide for drainage, the duct is designed with the necessary slope and condensation in the line itself is taken care of by traps.

No attempt is made to recover the condensate from the traps in the line, but condensation meters will be placed on them for the purpose of determining the losses.

A short distance from the point of entrance to the building of the Delco Light Co., the line crosses a small canal. As may be seen in the photograph, Fig. 9, the line at this point is only a few inches above the surface

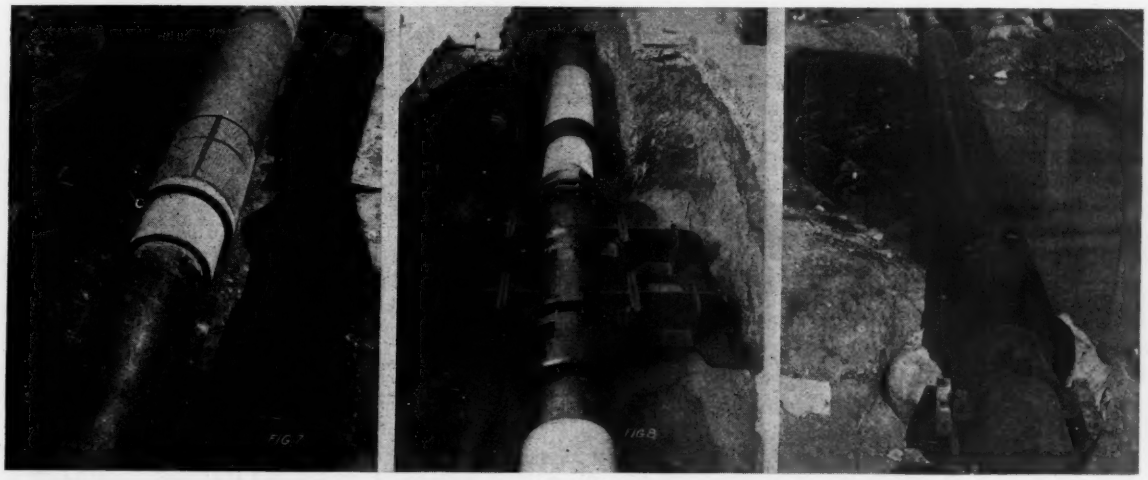


FIG. 7. PHOTOGRAPH OF LINE SHOWING DETAILS OF SUPPORT, WELDED JOINT AND INSULATING COVERING
FIG. 8. ONE OF THE DOUBLE AIR-COOLED EXPANSION JOINTS SHOWING SIDE ANCHORS BEFORE IMBEDDING IN CONCRETE
FIG. 9. PHOTOGRAPH OF CANAL CROSSING SHOWING WATER-PROOFED SHEET IRON COVERING

Pipe covering consists of two 1½-in. layers, or a total thickness of 3 in. of Asbestocel sectional, sponge felt covering banded in place with annealed iron wire. The inner layer of this covering is applied so as to break joints with the outer layer, and the whole laced in expanded metal lath, and hard finished with a ¼-in. layer of a mixture consisting of one-third Portland cement, one-third insulating cement, and one-third plasterers' sand. All fittings are covered with asbestos-sponge, felted block applied in sections and hard finished as described above.

The covered pipe is supported every 30 ft. by alinement guides held in place with concrete. Between these alinement guides, the pipe rests on rollers 10 ft. apart, supported on concrete pillows. The rollers and alinement guides permit free movement longitudinally while reducing the possibility of lateral displacement to a minimum. Improved type, air cooled expansion joints are located in the line 180 ft. apart. In most cases, these joints are double, that is, two of them are placed back to back, connected by a short nipple. They are firmly anchored at the sides in solid concrete as shown in the photograph, Fig. 8, and can easily take care of a movement of from 7 to 10 in. They are of extra heavy cast

of the water. The level of this canal, however, is automatically regulated between very narrow limits so there is no danger of the water rising and coming in contact with the pipe line. At this point the covering is the same as on other parts of the line except that an additional covering of sheet iron, thoroughly waterproofed, is provided. As an indication of the excellence of the insulation, it may be of interest to know that this exposed part has been repeatedly covered with snow and ice, without its melting.

Operation

While the line has not been in operation for a sufficient length of time to enable thorough tests being made for the purpose of determining the amount of heat lost by condensation, the indications are that this loss will be exceedingly small considering the size and length of the system. Friction losses are reduced to a minimum, both by the ample size of the piping, and, at the turns by the use of long radius bends.

Data and photographs used in the preparation of this article were secured through the courtesy of O. H. Hutchings, associate general manager, and L. C. Killen, of the Dayton Power and Light Co.

Application of Waste Heat Boilers to Open Hearth Furnaces*

Basic Principles Governing the Design of Successful Waste Heat Installations. By Thomas R. Tate

THE UTILIZATION of waste heat from open hearth furnaces is a subject that should appeal to the electrical engineer as well as to the metallurgical engineering profession. The latter are inclined to view it from the aspect of decreased cost per unit of production, while the former should consider it from the standpoint of reduced costs of power or additional capacity available for generating electric current and reduction in investment charges of the coal fired stand-by station.

Nearly all of the large steel companies have one or more waste heat boilers in service on their open hearth furnaces today. Some of these are experimental plants and have not given as satisfactory service as an installation made today with the present data available on this subject, would justify. Most of the difficulties have been due to insufficient, or too much draft, lack of proper draft control, improper location of boiler with respect to stack and induced draft fan, and to the presence of numerous air leaks through the checker-work in the waste heat flues and in the boiler setting. All of these troubles can be overcome in new installations, but it is somewhat difficult to obtain the most satisfactory arrangement when a waste heat boiler is added to an existing plant.

The results obtained from numerous tests lead to the following conclusions and theories with regard to the waste heat boiler, as applied to the open hearth furnace.

Design

THE DESIGN of the proper size and type boiler for any installation should be determined upon the basis of the weight of waste heat gases from any given size furnace and the tonnage rating of the furnace. This weight can be calculated from the amount of carbon content in the fuel and in the charge per ton of ingot steel produced and from analyses of the gases and their atomic weights. The average of several tests with producer gas show values of CO_2 of from 12 per cent to 16 per cent and of CO from zero to 0.6 per cent.

The draft on the furnace generally varies from 1.3 to 1.5 in. of water. The draft loss through the waste heat flues depends to a great extent upon the length of the flues, number of bends, etc.; but for average conditions and a gas velocity of 25 ft. per second, 0.1 in. of water should suffice. The draft loss through the boiler varies from 1½ to 3 in. of water, depending upon the type of boiler and the area of the gas passage and accumulation of dust on heating surface.

The temperature of the gases entering the boiler ranges from as low as 900 deg. F. in some installations to a maximum of 1400 deg. F. and varies considerably during a given heat. With a properly designed flue, and the boiler located within 20 to 30 ft. of the checkers, an average temperature of 1200 deg. F. should be obtained at entrance to the boiler.

Due to the fact that most of the heat transfer from the gases through metal heating surface to water comes from the principle of convection of heat and very little transfer is gained from radiation of heat, close attention must be paid to the principles promoting the efficiency of convection. These principles are general and basic and may be stated as follows:

Close confinement of the gases to the heating surface; long gas travel; ample time for the gases to be in contact with the heating surface; gravity or mechanical cleaning of heating surfaces to insure greatest efficiency, and no possibility for the gases to short circuit the heating surfaces, regardless of velocity.

The location of the boiler should be adjacent to the stack, on center line of the furnace. The waste heat flues should be designed to come directly from the checker work to the boiler, with a bypass around the boiler and fan and suitable bypass valve. If underground, these should be protected against heat losses and air leaks by from 3 to 4 ft. of earth. If overhead, they should consist of a steel pipe with a suitable firebrick lining.

Induced draft is absolutely essential to the success of any scheme of open hearth waste heat utilization. The fan drive should be determined from the standpoint of draft control and feed water heating.

Variable speed motors, constant speed squirrel-cage induction motors, steam turbine drive or steam engine drive may be used with satisfaction.

With variable speed motors, the speed and draft may be controlled from the melting platform. With constant speed motors it is necessary to use a damper, also controlled from the melting platform. With either a steam turbine or a steam engine, the speed and draft may be varied directly at the fan. The steam turbine affords the most flexible method of drive and of course gives ample exhaust steam for feed water heating.

Superheaters and Soot Blowing Equipment

SUPERHEATERS ARE a necessary adjunct of any power house and should not be omitted in any waste heat boiler installation. Their location should be such as to furnish the desired amount of superheat. Whether this be between the first and second passes, parallel to the first pass or located in the boiler entrance, should be determined for any given conditions and type of boiler used. The square feet of heating surface required for superheaters is approximately 10 per cent of the total square feet of boiler heating surface.

Soot blowers are absolutely essential for the successful operation of any waste heat boiler containing a large amount of dust in the waste heat gases and should be installed regardless of the type of boiler selected. If the heating surfaces are not kept clean, the average efficiency and percentage of normal rating obtained will rapidly fall, hence the installation of soot blowers as a prime requisite.

*Abstracted from a paper delivered before the Philadelphia Section, Association of Iron and Steel Electrical Engineers, Engineers' Club of Philadelphia.

Calculations of Waste Heat Boilers for Open Hearth Furnaces

There has been evolved from the tests made upon waste heat boilers a simple method for determining the horsepower which can be developed and the proper size boiler to be installed for the development of that horsepower, which is as follows:

$$B.HP. = W\,C\,E\,(T_1 - T_2) \div U\,L$$

In which:

B.HP. = Boiler horsepower; W = Pounds of gas available per hour; C = Specific heat of the gases; T_1 = Initial temperature of the gases entering the boiler; T_2 = Temperature of the gases leaving the boiler; E = Constant used to cover unaccountable losses, variation in dust accumulation on heating surface, etc.; U = Pounds of water evaporated from and at 212 deg. F. per hour per boiler horsepower; L = Latent boiler vaporization from and at 212 deg. F.

The co-efficient E appears from test results to have a value of between 85 and 90 per cent.

As an approximation, W may be assumed on the basis of 1000 lb. of gas per ton of output if operating on producer gas.

The specific heat C may be taken as 0.24 to 0.27 for most calculations.

The heating surface required in the boiler to develop the horsepower obtained by the foregoing formula may be obtained by the following formula:

$$S = W\,C\,(T_1 - T_2) \div R\,(T_1 + T_2 - t_1 - t_2)$$

In which:

W, C, T_1, T_2 are the same as above; R = Rate of heat transfer = B.t.u. per square foot of heating surface per degree temperature difference per hour; t_1 = Temperature of steam due to pressure; t_2 = Temperature of feed water; S = Square feet of heating surface.

The rate of heat transfer can be calculated or interpolated from a curve (See "Experiments on the Rate of Heat Transfer from a Hot Gas to a Cooler Metallic Surface," by the B. & W. Co.) provided gas passage area of the boiler is known in terms of weight of gases per square foot of flue area per hour. In open hearth waste heat boilers of the horizontal water tube type, this gas area is restricted to approximately 3500 lb. per sq. ft. of gas passage area per hour, and a high gas velocity thereby obtained.

The above formulas are approximate only but may be used for rough calculations to determine the proper size of boiler. The rate of heat transfer "R" varies considerably, however, with the gas velocity.

Value of Metering Fuel Oil and Water

By Allen F. Brewer

IT IS surprising today, in an age of ever-increasing efficiency of operation, how many modern power plants, which have been converted to the burning of oil fuel, have no means of determining their fuel consumption except by rough gaging of their storage tanks. Such plants, at large, do not even attempt to measure their boiler feed water. As a result, they operate virtually by instinct, with practically no knowledge of their rate of water evaporation obtained, nor of the per cent of horsepower rating they are attaining. In certain cases, such as refrigeration plants, where condensed steam is used for ice-making purposes, there is a real excuse for the absence of feed water measuring devices; but the majority of the power plants carry on with the idea that a fairly good percentage of CO_2, say 11 per cent, and no smoke at the stack, are reliable indications of efficient combustion. To a certain degree, they are good indications; but by no means can they be depended upon.

Benefits to be derived from the installation of water and fuel oil meters are so great that the knowledge and saving derived will more than pay for the first cost of such equipment in a very short time. For example, let us consider a power plant of four 150 rated horsepower, water-tube boilers. Their fuel oil consumption, operating at rated horsepower, would probably run in the neighborhood of 1000 gal. per boiler, per day of 24 hr. The water consumption would perhaps be about 10,000 to 15,000 gal. per boiler per day. An oil meter of the rotating disk type, size ¾ in., would easily and accurately record this oil in gallons. The first cost of such a meter, plus pipe fittings and labor to install, would be about $30. The water meter necessary could be, let us say, any standard type of 2 in., preferably one reading in gallons. The first cost of the latter, plus pipe fittings and labor to install, would reach about $190. Thus, a total first cost of, say, $220, would be our debit.

Now, to look on the credit side, as it were. Let us assume, after the meters are installed, that an evaporation of 10 lb. of water per pound of oil is shown; arriving at the pounds of oil from its average Baumé or specific gravity, and obtaining the pounds of water directly from the meter, or from the weight of water per gallon at the temperature of feeding.

It is perfectly evident that an evaporation of 10 lb., firing fuel oil, is lower than average; 13 lb. at least should be attained. Straightway the problem before the engineer is to find out what is wrong and how to correct it. A number of points must be considered: The condition of the boiler tubes and drum as to scale, sludge, etc.; the question of amount of excess air used; the efficiency of the burners, and their ability properly to atomize the oil; the amount of steam used for atomization; the temperature of flue gases; and finally, the construction of the boiler furnace, as to air intakes, etc. All these points must be considered, one by one, and proved correct, or steps taken to improve upon them. The boiler may be badly in need of cleaning, which is a most prevalent case. The burners may not be of sufficient size for the furnace. The air checkerwork, if any at all is installed, may be admitting entirely too much air, with the result that gases of combustion pass prematurely up the stack; a point which is indi-

cated by excessively high temperature of the flue gases. The latter, under proper operation, should range in the neighborhood of 500 deg. F.

After having checked up the above factors, one by one, proven them correct or made them so, there is no doubt but that the rate of evaporation and developed boiler horsepower will both be increased markedly. A few figures may be of interest to indicate the cash value in the saving of fuel from this point on.

Let us assume the rate of evaporation to have been increased from ten to thirteen pounds of water per pound of oil. Now, in order to obtain the same boiler horsepower output as formerly, i. e. 150, we would still evaporate the same amount of water—about 495,000 lb.; but with less oil burned. At 13 lb. evaporation this would amount to 38,300 lb. of oil, or approximately 4800 gal. Under old conditions, with an evaporation of 10 lb. of water per pound of oil fuel, there would have been required 49,700 lb. of oil. Thus, we have effected a saving of (49,700 — 38,300) 11,400 lb. of oil per day, to accomplish the same results in boiler output. This saving is equivalent to approximately 1425 gal., or about 34 bbl. of oil, of normal gravity.

At a cost of, let us say, $3 per barrel, this would amount to about $100 per day of 24 hr., with all boilers operating at normal rated horsepower, i. e. 150.

Of course the above figures are only approximate, and based on current high prices in general. Yet, it is evident that whatever the prices, the saving is so great that the cost of installing meters, and, if necessary, revising boiler construction, piping, etc., will be met in a very short time, and the general daily costs of fuel will be cut down about 20 per cent, whatever the market price may be, or the amount used.

Boiler Feed Water Regulation

EFFECTS UPON VARIOUS BOILER AUXILIARY EQUIPMENT AND FEED WATER TEMPERATURE. BY ROLAND MOELLER

EFFORTS in boiler feed regulation were first aimed at keeping the water level in the boiler as nearly constant as possible. Later it was realized that keeping the water level constant at all times had decided disadvantages. Prior to that time, automatic boiler feed regulation depended on mechanism which would give the feed water valve a full opening until a certain maximum water level had been reached in the boiler, and then would close off the feed water valve entirely until a certain lowest limit in the water level had again been reached. This gave an irregular intermittent feed, which insofar as its effect on the efficiency of the generation of steam was concerned, was not much of an improvement over hand regulation.

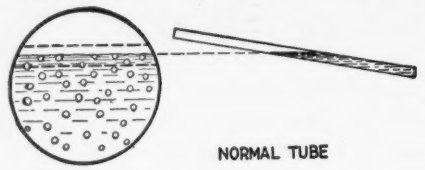


FIG. 1

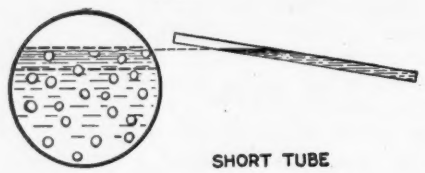


FIG. 2

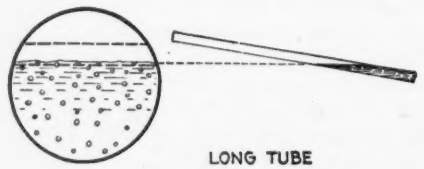


FIG 3

FIG. 1. WATER LEVEL AT NORMAL LOAD

FIG. 2. WATER LEVEL AT PEAK LOAD WITH SAME WEIGHT OF WATER IN BOILER AS IN FIG. 1

FIG. 3. WATER LEVEL AT LOW LOAD WITH SAME WEIGHT OF WATER IN BOILER AS IN FIG. 1.

While an automatic mechanical device that is absolutely reliable has never been made, there are many automatic mechanical devices which are far more reliable than a human being, especially where the apparatus is given a reasonable amount of care and attention. It is for this reason that a water regulator properly designed will add much to the safety of operating a plant.

The more intelligent help in the plant is relieved of a great deal of the strain and worry of watching the flow of feed water and its regulation, and the morale of the boiler room is increased to the extent that more interest is taken in other matters of vital importance having to do with the economy of the plant. Continuous flow of feed water with gradual variations in rate saves the boilers, heaters, economizers, meters, water pumps, piping, and all connections from shocks and strains due to violent and extreme fluctuations in the rate of feed water flow.

Continuous flow also makes possible the use of smaller feed pumps, feed water pipe lines, connections, valves, etc., because when the feed water supply is continuous, the rate of flow at any given time need not be as great as when water is fed intermittently.

As the equipment in boiler rooms became more and more involved with the addition of water softeners, economizers, feed water heaters, superheaters, temperature, steam and water meters and recorders, and other apparatus to promote economy and efficiency in the generation of steam, it became evident that the rate of flow in the feed water had a decided effect on the efficiency of all of this quipment and on the legibility of the charts produced by the various recording meters.

A water softener is calculated to handle a certain number of gallons of water per hour on the basis of a continuous even flow. Where the flow is intermittent and irregular, a much larger water softener must be installed to handle the same quantity of water and its

operation is far less satisfactory and economical than it would be if the flow of feed water were continuous and more closely in unison with the rate of steam output of the boiler.

The same is true of economizers and feed water heaters. When the flow of feed water through these is reduced, the feed water reaches an excessively high temperature and may even turn into steam, resulting in water hammer and other troubles in the feed water system. The apparatus under these conditions allows heat to escape without being absorbed. On the other hand, when at intervals the feed water valve is opened wide, the feed water rushes through at such a high rate that it is not warmed up to a temperature commensurate with economical boiler operation.

The rate of feed water flow has a decided effect upon the steaming capacity of a boiler itself. A full opening of the feed water valve may pass enough cold feed water into the boiler to absorb all the heat generated by its furnace without generating any steam whatsoever. Intermediate rates of feed water flow will, of course, reduce the steaming capacity of a boiler in proportion to the flow of the feed water.

Bearing this in mind, it is evident that there are frequent periods in the operation of a steam boiler when it would be desirable to reduce the rate of feed water flow so as to make possible the maximum generation of steam. This is particularly true after a period of low load when a sudden peak load comes on. Under these conditions, the furnace must be given time to catch up with the new peak load conditions, and if, during this time, the rate of feed water flow is temporarily reduced, the boiler has a far better chance to meet the sudden increased demand for steam, when little heat is being consumed in heating up feed water to the boiling point in the boiler.

On the other hand, should the load suddenly drop off after a high load period, it takes some time for the furnace to slow down to where it generates heat at a rate in harmony with new load conditions. It is then desirable to increase the rate of feed water flow temporarily so as to absorb the extra heat generated by the furnace during this brief period.

Again, where a large number of boilers are acting in unison, fewer boilers can be made to do the same work which would ordinarily require a larger number of boilers laboring without scientific feed water regulation. With unscientific feed water regulation the steam output of some of the boilers may be so affected by the admission of feed water during a high load crisis that their addition to the total steam supply is very much curtailed or even reduced to zero when it is most needed. With scientific regulation, on the other hand, all the boilers would be delivering their maximum output, the rate of feed water flow being reduced to a minimum in all of them at the same time to make this possible.

Good automatic feed water regulation requires, then, feeding continuously as long as there is a load on the boiler. It should temporarily reduce the rate of feed water flow when there is a sudden increase in load and temporarily increase the rate of feed water flow when there is a sudden decrease in load. It should keep the water level high under low loads and low under high loads. During steady loads it should maintain a constant water level by maintaining a constant rate of feed proportionate to the load. During gradual changes in the load it should gradually adjust the rate of feed in proportion to the changes in the boiler load.

A regulator functioning on these principles acts as a sort of compensating boiler governor; that is, it supplies the means of absorbing the excess heat generated by the furnace during the brief period following a sudden falling off of the load when the furnace has not yet had time to adjust itself to the new conditions. It prevents the absorption of heat by the feed water when the furnace has not yet had time to catch up with a sudden increase in load, and all the heat that is generated is required for steam making. It utilizes the volume represented by the difference in the levels of the water between the high and low water marks in the boiler as

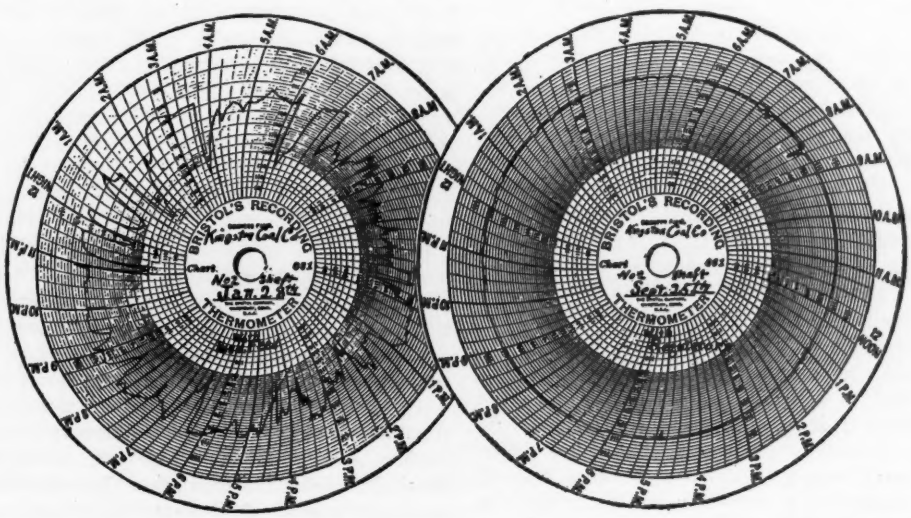


FIG. 4. FEED WATER TEMPERATURE RECORDS SHOWING, RESPECTIVELY, EFFECTS OF HAND AND AUTOMATIC FEED WATER REGULATION

a sort of heat reservoir, and so regulates the water level as to insure dry steam at all times. It guards against damage due to too high or too low water level at any time.

It has been conclusively demonstrated that the water level of a steaming boiler undergoes pronounced fluctuations which have a direct relation to the rate at which it is producing steam. This is due to the increased volume of steam bubbles present in the water when the steam output of the boiler is high. Figures 1, 2 and 3 show the variations in the water level in a steam boiler containing the same weight of water under normal, peak and low load conditions. This variation of water level according to load is one of the characteristics of steam boilers utilized in the inclined tube type of regulator.

In this feed water regulator, a metal tube having a large coefficient of expansion is connected to the boiler in such a way that the level of the water in this tube varies with the level of the water in the boiler. The water in the lower end of the tube, not being exposed to any source of heat, becomes comparatively cool, while the upper end of the tube above the water level is kept hot by steam from the boiler to which it is connected. As steam slowly condenses in the upper part of the tube, it is returned to the boiler through the lower end. If the water level in the boiler suddenly rises due to an increase in load as in Fig. 2, the level of the water in the tube also rises and the length of the tube above water containing hot steam is reduced. If, on the other hand, there is a dropping off of the water level due to a decrease in load as in Fig. 3, the length of the tube exposed to hot steam is increased by the amount the water level recedes in the tube. The portion of the tube which is exposed to the hot steam expands, and the greater the length that is so exposed, the greater the increase in the overall length of the tube. This difference in the overall length of the tube between high or low water is utilized to operate a valve which controls the rate of flow of the feed water.

When there is a sudden increase in the demand for steam, the water level in the boiler rises. The length of the tube exposed to the hot steam is decreased and the length exposed to the cooler water is increased. Consequently there is a contraction, and the overall length of the tube is decreased and this in turn reduces the opening of the feed water valve. If the high load continues, the level of the water will, of course, gradually drop off until the water level in the tube comes to a point where the feed water valve again begins to open. The opening increases gradually until a uniform rate of feed is reached, which is equivalent to the rate at which the water is used up in making steam. If the demand for steam is high, the demand for feed water is high, and the feed water valve must have a wide opening. To get this, the tube must expand more. This in turn can only be brought about by a lower water level, and that is exactly what is desired under high load conditions.

If, on the other hand, the demand for steam suddenly drops off after a continuous high load, the water level in the boiler falls immediately, and with it the level of the water in the tube. The length of the tube exposed to hot live steam is increased, causing an increase in its overall length. This in turn opens the feed water valve so as to admit water to the boiler at a greatly increased rate not only until the former level is reached, but until the level is higher than the one under high load conditions. To reduce the flow of feed water to conform to the reduced demand for steam, the opening of the feed water valve must be reduced to less than it was when the demand for steam was high, and to accomplish this the thermostatic tube must contract more. It does this only with a rise in the water level. Higher water level during low loads is very desirable for heat storage purposes as explained before, and is entirely permissible with light loads.

Two time-temperature charts shown in Fig. 4 are typical before and after records where one of these automatic thermostatic boiler feed regulators replaced hand regulation. The left-hand diagram shows an average feed water temperature of 178 deg., which was the best obtainable with hand regulation. The right-hand diagram shows an average feed water temperature of 210 deg., which resulted with automatic continuous flow regulation based on the principle here set forth. The average feed water temperature was therefore increased 32 deg. F., which is equivalent to a saving of 3 per cent in fuel.

Reducing Hazards in the Engine Room

Suggestions for Eliminating Dangers in Connection With the Operation of Reciprocating Engines

IT is often assumed that the stationary engineer has an easy job, and that his main duties consist in stopping and starting the engine at the beginning and end of working shifts, while in the meantime he sits in a comfortable chair, smokes his pipe, and reads the newspaper. Even owners of power plants appear to hold this opinion in some cases, and in order to put the "spare time" of the engineer to profitable use, they make him a sort of general factotum. The position calls for efficiency in various mechanical lines, and when some trifling job has to be done it is perhaps natural to wish it upon the engineer, because he will generally know just how to do it. To a limited extent, this is all right; but it can easily be overdone. He must never be required to leave the engine room to go to some other part of the factory to repair a disabled machine or to do other odd jobs. A plant operated on this basis is in constant danger, because at any moment conditions may arise in the engine room which may lead to a serious accident. The engine should never be left unattended, unless somebody competent and capable of doing the right thing in time of emergency is delegated to take the engineer's place.

The position of stationary engineer is an exceedingly responsible one, which calls for a high-grade, versatile man, having a broad general knowledge combined with a large amount of manual skill. The employment of a first-class engineer is the prime requisite for securing

safety, but many other matters must also receive attention if the plant is to be properly protected, and some of these are mentioned in the following.

Flywheels

Of the more serious accidents that occur in connection with steam engines, are those due to the bursting of flywheels. The principal causes of flywheel explosions are excessive speed, sudden and extreme variations in the load, and defects in the wheels.

A sudden increase in the load on an engine may produce exceedingly heavy stresses in the flywheel. The momentum of the rim tends to produce severe stresses in the spokes and the hub, and fracture may result unless the wheel is designed for service of this sort and unless it is in good condition. Flywheels of rolling mill engines are subject to extraordinarily heavy duty of this kind, and must be built with special reference to violent changes in speed.

Every flywheel, whether subject to sudden variations in load or not, should be examined frequently by expert inspectors for the detection of weaknesses and defects.

The speed at which a flywheel may be safely run depends upon the design of the wheel, the material of which it is constructed, and to some extent upon the conditions under which the engine is operated. The limit at which the speed ceases to be safe should be determined by the use of approved rules and formulas.

Speed Governors

Comparatively few of the accidents that arise from excessive speed are caused by intentionally increasing the speed. Most of them are caused by the failure of governing mechanism or sudden fluctuation from full load to no load (such as might be caused by the breaking of the main belt).

Frequent examination of the entire governing mechanism is essential. The belts of belt-driven governors should be kept at the proper tension and free from oil and grease, which would cause them to slip.

See, furthermore, that the key or set screw that secures the governor pulley to its shaft is kept tight and that gears on gear driven governors are in good condition. Provide suitable guards for the balls of fly-ball governors, particularly when they are located near oilers' walks or passageways. Basket shaped guards, made of sheet metal or stout wire netting, are often used for this purpose. A good type is shown in Fig. 1.

A positive stop should never be placed under the governor rod. When a governor-rod stop is needed to facilitate starting the engine, an automatic device should be provided, which will drop out of the way as soon as the rod rises, and thus leave a clear path for the rod to descend to its lowest position.

A governor safety stop should be provided in connection with each fly-ball governor. This may be operated electrically or mechanically and should be arranged so that when the governor rod descends to a dangerously low position, a spring or some other device will be released, which will close the throttle valve.

Automatic Speed-Limit Stops

Automatic speed-limit stops, designed to limit the speed of the engine independently, are often installed in addition to the governor, and an approved device of this kind is strongly recommended. These devices, when provided, should receive proper care, and should frequently be tested to insure dependability. When they are electrically operated, the circuits should be tested frequently to detect possible short circuits and to make certain that there is sufficient current to operate these devices. The batteries and conducting wires should always be located so that they cannot be damaged by a broken main driving belt, nor in consequence of any other accident which might accompany the racing of the engine. Many plants that are elaborately provided with independent engine stops show the greatest imaginable lack of forethought with respect to the protection of the apparatus against damage from the very causes that may lead the engine to run away.

Miscellaneous Protective Devices

When a condenser of the jet type is used, an automatic device should be installed which will break the

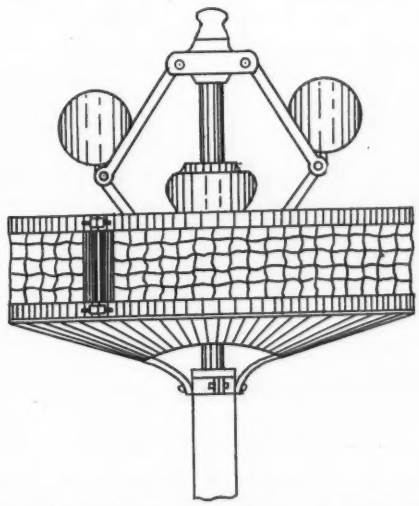


Fig. 1. A good basket guard for a flyball governor

vacuum when the water in the condenser reaches a dangerous height. If no such vacuum breaker, as they are termed, is installed, and if the air pump is of the attached type, any slowing down of the engine is likely to cause the condenser to become flooded; in which case water would flow back into the engine cylinders, with consequent liability to wrecking.

The control lever or wheel which operates the throttle valve is frequently located directly in the plane of the flywheel, where the engineer is exposed to the greatest possibility of danger when he undertakes to stop a racing engine. When the throttle valve is located in such a dangerous place, it is recommended to extend the spindle (when this is possible), so that the lever or wheel which operates it can be manipulated from a position of comparative safety.

Guards

Engine flywheels should be guarded by substantial railings made of pipe or angle iron, or by inclosures of some other acceptable kind to prevent persons from coming in contact with them. When railings are used, and the wheel runs in a pit, a toe-board at least 6 in.

high should be provided to prevent tools and other objects from falling into the pit. Inclosures may be constructed of solid, perforated, or expanded metal or of substantial wire netting. Employes should never be allowed to store oil cans, tools, waste, or other objects inside of these railings or screens, nor to hang clothing upon them. For the purpose of turning the flywheel over by hand or by means of a Johnson bar, the guard rails or inclosures are sometimes made removable at some point. This is not advisable, however. There should be no gates in the inclosures or railings and any openings that may be provided for the insertion and application of a Johnson bar should be limited to the smallest size permissible. It is extremely dangerous to turn the wheel over in this way without making sure beforehand that the throttle valve is closed tight and that there is no pressure in the cylinder.

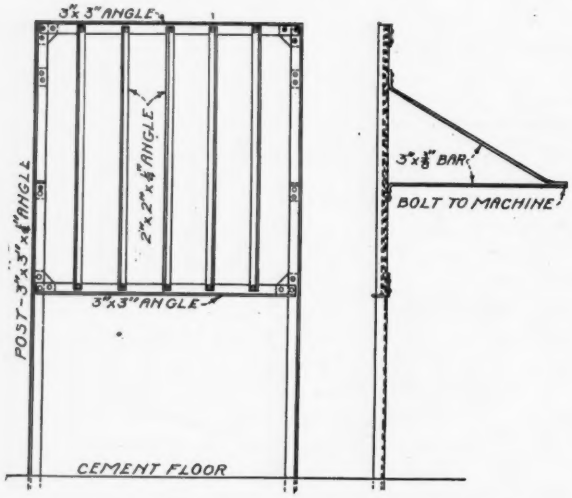


FIG. 2. DETAILS OF BARRIER BELT GUARD

The foregoing suggestions in regard to flywheel railings also apply in connection with the guarding of main belts or rope drives. Substantial guards should in addition be provided for the cranks, crossheads, connecting and tail rods of engines.

When the main driving belt of an engine breaks it is likely to do a great deal of damage, and any person who is struck by it may be killed or seriously injured. An excellent form of barrier for guarding a heavy main belt and preventing it from doing serious damage in the event of a break is shown in Fig. 2. The angle bars that form the grating bars are vertical, this being an important feature because if the belt should break the lash of the broken ends will be resisted by several or all of the bars. It is highly important, not only to secure the guard solidly at the bottom, but also to anchor it safely at certain points higher up so that it cannot be bent over by a blow from the belt. The details of the anchorage must necessarily depend upon the conditions that prevail where the guard is installed. If possible, it is advisable to attach one of the guard supports directly to one of pillow blocks of the shaft.

For the purpose of diminishing the danger due to the blowing off or bursting of a cylinder head, heavy plate barrier guards should be placed opposite every cylinder head and close to it. Guards of this kind should be solidly supported, but should be so arranged that they may be removed by means of a crane when it becomes necessary to get at the cylinder heads.

It should hardly be necessary to refer to the importance of keeping the cylinders of engines free from water, yet piston rods are frequently bent and cylinder heads are often fractured, in consequence of neglecting this simple and elementary precaution. The water may back up into the cylinder from the condenser (as described above), or it may come over with the steam in consequence of foaming or priming in the boilers, or it may accumulate in the cylinder from the condensation of the steam admitted to a cold engine preparatory to starting it up, or, as happens all too commonly, its presence may be due to the simple fact that the steam main was not properly drained.

Starting the Engine

Before starting the engine, drain the steam mains thoroughly in every part. Then open drain cocks on all cylinders, and if water runs out wait until it has ceased to flow. Then, leaving the drains still open, start the throttle valve a mere trifle (or, in technical language, "crack" it a little) and allow steam to enter the cylinder so that it will gradually become heated up to working temperature. If the engine is compound, all the cylinders should be warmed in the same way by opening the passover valves. The jackets should also be filled with steam, careful attention being given to the draining of these jackets. When the cylinders have become thoroughly warm, the engine may be turned over slowly, but the drain cock should be left open until all danger of the collection of water in the steam chest and cylinders is past.

General Precautions

Before removing a cylinder head, make sure that the throttle and exhaust valves are both closed and that the drains are open to show that no pressure exists in the cylinder.

See that all moving parts of the engine are kept thoroughly lubricated and use the right kind of lubricant in each place. Lubricating devices should be examined frequently to insure proper adjustment at all times.

All parts of the engine should be kept in good adjustment, and if knocks or other unusual or abnormal noises are noted, locate them immediately, ascertain their cause, and apply the proper remedy.

Slippery floors in engine rooms frequently cause falls, and a slip-proof surface of rubber, or other approved non-slip material, should, therefore, be provided wherever slipping would be attended by special danger.

Employes from other departments of the plant should not be permitted to loiter in engine rooms, nor even to enter them except as their duties may require them to do so. No person other than those responsible for the operation of the engines should be permitted to manipulate any valves, nor even to touch any of the mechanism, nor to approach any moving part, except under the direction and supervision of the chief engineer or some other person of authority.

The foregoing material was abstracted from Reciprocating Engines and Steam Turbines, a booklet issued by the Travelers Indemnity Co., to whom credit is hereby extended.

As a Man Thinketh

By H. A. Cranford

As a man thinketh in his heart, so is he, is a saying that is proven true every day; and it is especially applicable to engineers. Every once in a while I meet some man in our line of work that seems to think that the whole world is against him, and it is not very long until he begins to go down.

No engineer is a better engineer than he believes in his heart he is; and until he has gained a reasonable amount of confidence in himself, he will not inspire a great amount of confidence in others. I have in mind a friend of long acquaintance. This man was one of the best; but where he was employed, the plant was all old. He got along fine for a while after taking charge. But pretty soon after the great war started. The plant got a big batch of government orders. They began to crowd on all the load that they could in order to meet the time limit. The power plant was soon taxed to its capacity. The result was that pretty soon the overload began to tell on the old units and things started happening. My friend drove himself day and night almost to hold up things. The result was that because he could not do the impossible he began to doubt his own ability as an engineer.

The time came when they were shutting down part of the time, and then the owners called him in for the reason. He had lost confidence in himself and his explanation did not sound convincing. They wanted to know why, if he knew the plant was being taxed beyond its capacity, he had not taken the matter up with them soon enough for them to prepare. His excuse was lame, so they let him go. When they hired a new man, he convinced them in a short time that he knew the trouble but would have to have some time to install additional power before they could hope to run steady; but that if they wanted him to do the best he could as things stood, he was there to get the most that it was possible to get out of what they had.

The last man is making good although, as an engineer, the first man was far his superior. But the first man didn't believe in his heart that he was right in his judgment, so he failed. Today he is still sliding down the scale and it won't be long until another good engineer goes to the discard.

Now, it isn't possible for every engineer to be the best engineer, but it is possible for every engineer to be the best engineer for the especial job that he happens to be on; and if the most of us would get busy studying every detail of our plants, every day in the year, then no other man could be a better man in that particular place. And the closer we attend to business, the better we become acquainted with our plant as well as ourselves. And the closer we become acquainted with ourselves, the more confidence we have.

An old poultry man once told me that the best place in the world to study the poultry business was to take a chair to the poultry yard every day and watch the chickens. Now the trouble with some engineers is, they go over the engine room and make what repairs are needed, give things the once-over, then hunt a cool spot by the window where they can study the "chickens" instead of studying the things in the engine room.

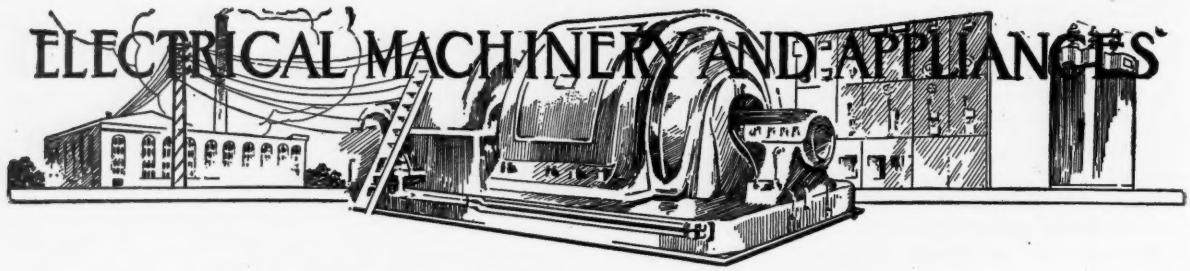
The truest indication of the condition of any business is to take stock and then make a trial balance. It would be a great idea if we would all sit down occasionally and take stock, look our failures square in the face and see what was the cause of them. In my own case, I find that the fellow who answers to my name was to blame about 90 per cent of the time. Next, look at the big things that you have put over and analyze the cause of them. Nearly every time you will find that you are due credit for them. Then make up your trial balance and if there are more failures against you than there are credits, and you have been in the game very long, it's a pretty good time for you to seek some field that is better suited to you. Most of us who have been in it very long, however, will find the balance on the right side of the sheet, with a good safe margin, enough to increase our confidence to the point where we can believe in our hearts that we are honest-to-goodness engineers; and then we are in shape to progress.

It has been my lot to start many young men in this work. I have always put in more time trying to instill self-confidence in their very souls than I have to teach them mechanical and electrical principles. After all it is only common sense and confidence that a man needs, provided, of course, that he has a reasonable amount of talent for the work. If he has no talent but has a reasonable amount of common sense, he will discover that he is wasting his time and get out of the work anyway without anybody asking him to.

The most pitiful man I ever met was one who had lost confidence in himself. If you suggested that he try a certain thing, he was afraid he would fail. He was afraid of everything. And when he came to die, although he had lived what we term a Christian life, he was afraid to die. And to my mind it was for good reason, too; because with all the wonderful opportunities that the Creator has placed here for us, and made accomplishment of everything possible, the man who not only fails to try, but fails to try to the very last, is going to have cause to fear the hereafter.

Read the biographies of successful men. All through the pages, belief in themselves and their ability to accomplish a certain thing breathes itself into every page. As a man thinketh in his heart, so is he. If you think you are a good man in your line, simply measure yourself up to the marks that constitute a good man occasionally. If you are a good man, you will be better for the comparison. If you are not as good as you were inclined to think you were, you will become a better man by seeing your defects and getting busy to remedy them. And if it did not make us actually better to look at ourselves, it is at least better to know the truth about a matter than to be laboring along under false impressions.

Get back in your engine room. Study each piece of machinery that is under your care. If there is anything you don't understand about it, get busy and find out about it. Keep your mind on your work until you find the solution to your problems and every time you master something you will "believe in your heart" that you are a better man in your line; and to the man who "believes in his heart" that he is a good engineer there can only be success for the future.



Electrical Features of Motor Installations

FACTORS REQUIRING CONSIDERATION FOR SUCCESSFUL OPERATION. BY GORDON FOX

SETTING and mechanical connection of a motor is essentially a mechanical job. A few electrical considerations enter, however. The motor should be located as favorably as possible, both from the viewpoint of cleanliness and accessibility. The shaft should be properly leveled and, in case of coupled drives or with herringbone or shrouded gears, the motor must be properly alined with respect to its magnetic center to prevent end pounding or end thrust and bearing troubles.

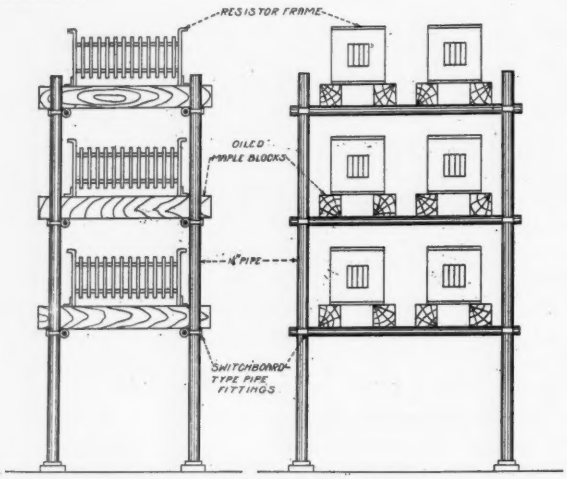


FIG. 1. RESISTOR RACK

Frames of motors should be grounded. An exception may be allowed, if necessary, only when it is impossible for an operator or attendant to make contact with the motor and with any grounded object at the same time. If the motor is not grounded, the isolation must be complete. The safest practice is to ground the motor frame, always.

CONTROLLERS

LOCATION FOR the controller is largely a matter of convenience. The controller should not be unnecessarily exposed, either to damage, dirt or accidental contact. Where permissible, the control may well be located between motor and source of power to obtain the most direct wiring runs. Safety dictates that all live parts be protected. Suitable protection may be provided either by enclosure or by isolation. Manual controllers should be substantially enclosed. Magnetic control panels may be enclosed or may be located in some clean, light place accessible to authorized electricians only. Magnetic control will not long survive and function properly if subjected to frequent "adjustment" by machine operators.

Mounting of grid resistors deserves mention. It is the best practice to mount the resistor frames on oil filled hardwood timbers or otherwise to insulate them from the ground, thus lessening the probability of failure and trouble. The frames should be stacked so as to provide good ventilation and should preferably be individually mounted so that they may be removed for repairs or replacement as independent units. Figure 1 shows a pipe rack supporting resistor frames.

WIRING CONSIDERATIONS

THE WIRING of motors and controllers is essentially a question of electric power distribution. The primary purposes and requirements of an industrial electric distribution system may be briefly stated as follows:

To convey electric power to motors.
To protect motors and distributing lines.
To isolate trouble.
To disconnect units for cause.
To meter consumption as required.
To provide for changes and extensions.

Wire and cable are used almost exclusively to convey electric power. The selection of wire size must be adapted to the load and is determined by the following limiting factors:

Heating—Insulated wire and cable deteriorates if safe temperatures are exceeded.

Voltage drop and power loss represent a similar condition from two different angles. Voltage drop may be due to both resistance and reactance whereas power loss is due to resistance only. In the case of large cables carrying heavy currents at low voltages, reactance drop is of first importance.

Mechanical strength—It is often desirable to use wire larger than necessary electrically, to insure proper mechanical strength. Cable is superior to wire in this respect. Solid wire in the smaller sizes should never be used on cranes or other moving machinery subject to vibration, as it will crystallize in time and break. The best practice on important drives is to use nothing smaller than No. 10 stranded cable for main leads, shunt field leads or control wiring.

Inspection—Underwriters' rules or local inspection regulations are frequently a determining factor. It is

not advisable to follow these rules alone, however, as they are based on the heating limitation only and represent merely acceptable practice, not necessarily the best.

As the sizes of distributing cables are governed primarily by their loading, the determination of the motor current demand is necessary. The current demand of a direct-current motor depends upon its horsepower output, voltage, and efficiency. In the case of alternating-current motors the additional item, power factor, enters. The exact current ratings of different motors of the same horsepower differ slightly, particularly in the case of alternating-current motors.

check on voltage drop for any motor with any suitable wire and for any distance is thus obtained.

Variable speed motors of crane and mill types are commonly given a number of different intermittent ratings. For instance, a certain mill frame type motor has the following ratings:

Half hour.....37½ hp. Two hours.....25 hp.
One hour.....30 hp. Five hours.....20 hp.

If this motor is to be operated continuously the wiring may well be based on the 5-hr. rating. If the motor is to be used intermittently, larger wiring will be re-

TABLE I. D.C. MOTOR CURRENTS AND VOLTS DROP FOR CABLES NECESSARY FOR CONTINUOUS RATED MOTORS

Sectional Area in C.M.					2582	4106	6529	10,381	16,509	26,250	33,102	41,742	52,633	66,373	83,694	105,502	133,079	167,806	211,600
Diameter in inches.					.051	.064	.081	.102	.128	.162	.182	.204	.229	.258	.289	.325	.365	.410	.460
Pounds Bare Copper Per 1000 Ft.					7.81	12.4	19.7	31.4	49.9	79.4	100	126	159	201	253	319	402	507	640
Safe Carrying Capacity in Amps.					6	12	17	25	33	45	53	63	75	88	100	125	150	181	218
Gage No. B and S					16	14	12	10	8	6	5	4	3	2	1	0	00	000	0000
H.P. at 110 Volts	H.P. at 220 Volts	H.P. at 500 Volts	Amperes Load of Motor	125% Amp. Load of Motor	Distance in Feet That The Different "Horse Powers" Can be Transmitted With One Volt Loss Note:-This table is based on two leads to the motor.														
		½	1.00	1.25	121	192	308	490	778	1,232	1,560	1,920	2,433	3,122	3,940	4,928	6,271	8,907	9,971
		1	2.00	2.50	60	96	154	245	389	616	780	960	1,216	1,561	1,970	2,464	3,135	4,453	4,985
	½		2.50	2.87	52	83	135	213	348	535	680	834	1,057	1,357	1,713	2,142	2,726	3,872	4,335
		2	4.00	5.00	30	48	77	122	194	308	390	480	608	780	985	1,232	1,567	2,226	2,492
½	1		4.50	5.62	27	43	68	108	173	273	346	426	540	700	875	1,095	1,395	1,975	2,215
		3	6.00	7.50	20	32	51	81	127	205	260	320	405	520	656	821	1,045	1,484	1,661
		4	7.50	9.37		25	40	65	104	164	208	255	328	416	525	657	836	1,187	1,330
1	2		9.00	11.25		21	34	54	86	137	173	213	270	347	438	547	697	990	1,108
			9.30	11.62		20	33	53	84	132	167	206	261	335	423	530	674	947	1,072
	3	7½	12.50	15.62		15	24	40	61	100	125	153	194	250	315	394	501	712	798
		10	16.50	20.62			18	29	47	76	96	118	147	189	239	298	380	539	604
2	4		18.00	22.50				27	43	68	86	106	135	173	219	273	348	495	524
	5		21.10	26.37				25	37	58	77	91	115	146	186	233	297	422	472
3		15	25.00	31.25				20	30	50	62	76	97	125	157	197	250	356	399
	7½		28.20	35.25					27	43	55	68	86	110	140	174	222	315	353
4		20	33.15	41.43					23	37	47	58	76	94	119	148	189	271	300
	10		37.60	47.00						32	41	51	64	83	104	131	164	236	265
5		25	42.00	52.50						29	38	45	58	73	93	116	143	211	236
		30	49.70	62.12							31	39	49	64	79	99	126	179	200
7½	15		56.50	70.62								34	43	55	70	87	111	157	176
		40	66.30	82.87									36	47	60	79	95	135	150
10	20		75.30	94.12									32	41	52	65	82	118	132
		50	82.80	103.50										37	47	59	75	107	120
	25		94.10	117.62											41	52	66	94	106
		60	99.40	124.25											39	49	63	89	100
15	30		113.00	141.25												43	55	78	88
		70	116.00	145.00												42	54	76	85
		80	132.00	176.00													47	67	74
20	40	90	150.00	187.50													41	59	66
		100	165.00	206.25														54	60
25	50		188.00	235.00														47	53
		120	198.00	247.50															50
30	60		226.00	282.50															44

Example:-
A 15 H.P. motor of 220 V. is located 400 ft. from the source of power and eight volts is the amount allowed for loss in service wire; what size service wire will be required?

Answer.
Eight volts loss in 400 ft. distance means a loss of one volt for every one-eighth of 400 ft. or one volt loss in 50 feet. Referring to the table, we find 15 H.P. under 220 volts can be transmitted 43 ft. on No. 3 wire, or 55 ft. on No. 2 wire. No. 2 wire is the size of wire desired, as No. 3 falls short of the requirements.

Table I will be found useful for selecting wire size and checking voltage drop of continuous rated direct-current motors of any voltage. The table shows the full load and 125 per cent load amperes of various motors. The allowed safe capacity of various wire sizes is shown among the column headings. A wire size should be selected having a capacity of 125 per cent motor ampere rating. The length of circuit one way which will cause one volt drop is shown. Greater distances cause proportionately greater voltage drop. Where four wires run to the motor, the drop is double that shown. A ready

quired; but it should not be required that a motor rated at 37½ hp. for ½ hr. should take the same size wire as a motor capable of carrying 37½ hp. continuously. Table II gives wire sizes which have been extensively and successfully used for connecting intermittent rated, variable-speed, direct-current motors. Either the half-hour or one-hour ratings may be used in connection with this table. This does not conform with rule 8(b) of the Code which demands liberal wire sizes, apparently due to confusion of wire capacity and fuse protection. In the case of intermittent rated motors, the voltage drop

should be checked on the basis of the short-time rating selected. Table II is based on runs including not more than 2000 ft. of wire.

Code wiring requirement for induction motors is rather involved and empirical. It is based on starting current inrush which is taken at 250 per cent load current for small motors and tapered to 150 per cent for large motors. This is modified by permitting higher wire capacity values corresponding to weatherproof wire. Table III gives conservative values of full-load current of induction motors together with corresponding wire, switch and fuse sizes required by the Code. An additional column gives wire sizes determined on the basis of 125 per cent load current and safe capacity of rubber covered wire. Voltage drop is not considered and must be checked separately.

TABLE II. WIRE SIZES FOR INTERMITTENT RATED D.C. MOTORS

Sizes refer to 230 volt and 500 volt motors respectively.		
H.P.	230 V.	500 V.
5	# 8	# 8
10	8	8
15	6	8
20	4	8
25	2	8
30	2	6
40	0	6
50	00	4
60	0000	2
75	0000	2
100	300,000cm.	0

The data given above applies to the wiring of individual motors. Mains and feeders to groups of motors need not be based on the full connected loads as the diversity factor plays a part in reducing the average demand. In determining feeder sizes, the continuity of loading of the various motors, the number of motors connected and the size of the largest motor all have a bearing. The average demand may vary between limits of perhaps 20 to 100 per cent of the connected demand. The mains and feeders should be capable of handling the average demand with a reasonable margin of safety.

It often occurs that it is not possible to predetermine the number and sizes of motors that will be installed in a given area. In some cases, departments may be moved, extended or contracted to meet business requirements, involving changes in machine and motor layouts. In designing a distribution system to and for such a location the copper requirement may be based on an arbitrary figure. It has been found in several cases that a value of about 2.5 w. per square foot floor area represents the power requirement of the average machine shop and factory installation of similar character. The feeders, based on this demand, may be run to distributing boards or cabinets about the space involved. Individual circuits may then be taken off to motors as required. Provision should be left open for running additional copper should this become necessary.

Bare copper wire is used comparatively little for power distribution purposes, except as a trolley. Open wiring, using weatherproof or slow-burning wire is still employed to some extent. The use of conduit is increasing. Rubber covered wire is most extensively used in conduit. There are many grades of rubber covered wire. New Code wire is a minimum acceptable quality. For important work, 30 per cent Para rubber or better grades should be selected. The Code requires multiple conductor metal sheathed cable in conduit for high-potential motor wiring except in power houses or substations.

Rubber covered wire has a shortcoming in that rubber deteriorates, particularly at the higher temperatures. The maximum temperature allowable by A. I. E. E. rating to avoid excessive depreciation is 60 deg. C. Varnished cambric with weatherproof braid insulation has advantage in that it does not deteriorate so rapidly, a temperature of 75 deg. C. being permitted by A. I. E. E. rating. This class of insulation is therefore better adapted for hot locations. Kerite insulation is a compound which does not contain rubber, but has similar qualities except that it does not deteriorate with heat, oil, etc.

CONDUITS

A MATTER of considerable importance is the location of conduits. They should never be run above and in close proximity to furnaces, flues or hot pipes. Conduits which are buried underground permit of little heat radiation. When wiring is to pass through buried conduits, the wire sizes should be liberal. Conduits buried underground should be somewhat isolated from each other. If grouped together too closely, they may cause hot spots leading to rapid deterioration of the insulation and subsequent failure.

Size of conduits used depends upon the cable contained. In wiring small direct-current motors, all wires may well be pulled in one conduit. With larger motors, it is advisable to run shunt field leads separately. Control circuit wiring should not be mixed with motor wiring. It is an excellent plan to use, for control pilot

TABLE III. WIRE SIZES FOR A.C. MOTORS

Sizes of wire, fuses and switches for use with squirrel cage continuous rated induction motors. Voltage drop not considered. Use next larger wire for motors below 600 R.P.M. Use last column for wound rotor motors.

220 volt motors- 3 phase- 60 cycles.						
H.P.	Ave.Amp. Rating.	Wire Size Code	Switch Amps.	Starting Fuse	Running Fuse	Wire Size based on 125 % load.
1	3.8	14	15	10	5	14
3	9.5	12	25	25	15	14
5	15.4	10	50	35	20	12
7.5	22.4	8	50	45	30	8
10	29	6	75	65	40	7
15	42.5	4	100	100	60	5
20	55	2	150	130	75	4
25	68	1	150	150	95	2
30	80	0	200	200	100	1
40	105	00	300	225	150	00
50	130	000	300	250	175	000
75	192	300Mcm	400	400	275	250Mcm
100	252	450Mcm	500	550	350	400Mcm
150	368	600Mcm	800	850	550	600Mcm
200	484	1Mcm	1000	1150	725	900Mcm
440 volt motors- 3 phase- 60 cycles						
1	1.8	14	15	5	3	14
3	4.8	14	15	15	7	14
5	7.8	14	25	20	10	14
7.5	11	10	25	25	15	14
10	15	9	50	35	20	12
15	21	8	50	50	30	10
20	27	7	75	75	40	8
25	34	6	75	75	50	7
30	40	5	75	90	55	6
40	52	3	150	135	75	4
50	65	2	150	175	90	3
75	96	0	300	225	140	0
100	126	000	300	275	175	00
150	184	250Mcm	400	400	275	0000
200	242	400Mcm	500	550	350	400Mcm

circuits, multiple conductor cable with colored braids or tracers for identifying the individual conductors without ringing them out. It is sometimes cheaper to run very large cables in individual conduits, as conduit above 2-in. is difficult to work and a group of large cables may be hard to pull. Alternating-current leads must be combined so that like wires of all phases are in one conduit. The magnetic fields surrounding the individual conductors are then neutralized. If this is not done, currents may be induced in the conduit, causing it to heat.

It is standard practice to install empty conduit and to draw in the wire or cable after the conduit is in place. For this reason, it is desirable to restrict the number of bends and to have any necessary bends of large radius. It should not be attempted to pull cable around more than four bends and even this number is high if the runs are long or cables heavy. Where a number of bends are involved junction boxes or fittings should be inserted in the conduit runs to permit pulling the cable in sections. The use of extra large conduits is sometimes desirable where bends are involved.

Conduits should be maintained internally clean during construction and the ends should be plugged. If water or dirt gets into a conduit, compressed air may be used to blow it out. A conduit may be swabbed out with cotton waste drawn through by a wire. Conduits should

TABLE IV. WIRE CAPACITY OF CONDUITS

SIZE OF WIRE B and S GAGE	Diameter Rubber Insul. Double Braid in 32 Ds. in.	NO. OF WIRES IN ONE CONDUIT								
		1	2	3	4	5	6	7	8	9
14	8	½	½	¾	¾	1	1	1	1	1¼
12	9	½	¾	¾	¾	1	1	1¼	1¼	1¼
10	10	½	¾	1	1	1	1¼	1¼	1¼	1¼
8	11	¾	1	1¼	1¼	1¼	1¼	1¼	1½	1½
6	14	¾	1	1¼	1¼	1½	1½	1½	2	2
5	15	¾	1¼	1¼	1¼	1½	2	2	2	2½
4	16	¾	1¼	1¼	1½	1½	2	2	2	2½
3	17	¾	1¼	1½	1½	2	2	2	2½	2½
2	19	1	1½	1½	2	2	2½	2½	2½	3
1	21	1	1½	2	2	2½	2½	3	3	3
0	23	1	2	2	2	2½	3	3	3	3½
00	24	1	2	2	2½	2½	3	3	3	3½
000	26	1¼	2	2½	2½	3	3	3½	3½	3½
0000	28	1¼	2	2½	3	3	3½	3½	3½	
200,000 C.M.	29	1¼	2	2½	2½					
250,000 "	30	1¼	2½	2½	3					
300,000 "	32	1½	2½	3	3					
350,000 "	1"- 2	1½	3	3	3½					
400,000 "	1"- 3	1½	3	3	3½					
450,000 "	1"- 5	1½	3	3	3½					
500,000 "	1"- 6	1½	3	3	3½					

not be installed in places subject to rapid fluctuations in temperature, as sweating will likely result, causing internal moisture. Conduits which run underground should not come in contact with cinders or other decomposing materials. The life of underground iron conduit subject to deterioration may be extended by wrapping with burlap strip and filling with tar. The ends of conduits should preferably terminate in some form of fitting "looking down" so that dirt and moisture will not enter. The practice is sometimes followed to fill the terminal fittings with wax or compound to seal them off. Where long vertical runs are involved, the cable should be anchored at intervals to relieve the tension due to its weight and to prevent injury by settling.

Size of conduits for containing various numbers of cables of like size are shown in Table IV. This refers to cables for ordinary low-voltage work. For wires having extra heavy insulation, the chart, Fig. 2, may be used, the outside diameter of the cable used being known. Where a number of cables of different sizes are to be installed in one conduit Table V may be used. This is based on the conduit area available as compared with that occupied by the wires. An example is given to show the application.

Protective Devices

Protective devices are employed in connection with the control of a motor for the following purposes:

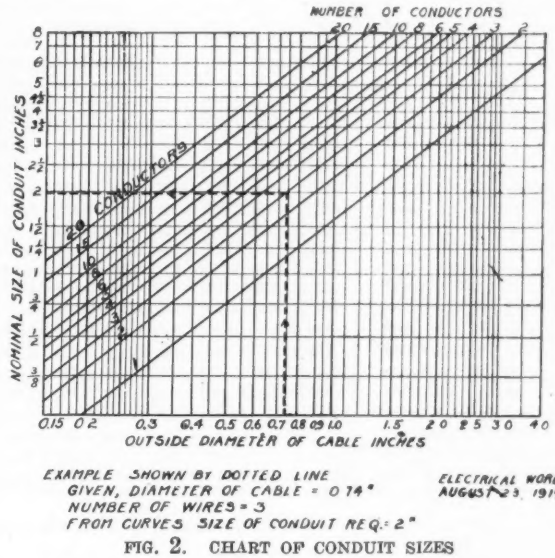

NUMBER OF CONDUCTORS
20 15 10 8 6 5 4 3 2
NOMINAL SIZE OF CONDUIT INCHES
OUTSIDE DIAMETER OF CABLE INCHES
EXAMPLE SHOWN BY DOTTED LINE
GIVEN, DIAMETER OF CABLE = 0.74"
NUMBER OF WIRES = 3
FROM CURVES SIZE OF CONDUIT REQ. = 2"
ELECTRICAL WORLD AUGUST 23 1919

FIG. 2. CHART OF CONDUIT SIZES

To protect the motor and control from injury from either severe or sustained overloads arising from electrical faults or mechanical overloading.

To protect driven machinery from damage from excess motor torque in a case of overloading or jamming or incorrect action of the control.

To isolate troubles and confine them to the motor involved.

To protect motor wiring.

Protective devices at feeder panels or distributing switchboards serve primarily:

To isolate and confine troubles.

To protect wiring from injury from overloading or faults.

The most common types of protective devices are fuses, circuit breakers and overload relays in conjunction with contactors or switches. Fuses are relatively cheap in first cost, but renewal costs may be high if fluctuating loads or other conditions render frequent renewal necessary. The difficulty in locating a blown fuse and the time of renewal are sometimes disadvantages. Circuit breakers have the advantage of low maintenance cost, quick indication of opening and quick reset and may be arranged for remote control if desired, both as to opening and closing. Circuit breakers are now available which will open on overload or short cir-

cuit and will reclose again automatically after a short interval if the faulty condition is cleared. Overload relays find common use in connection with magnetic controllers and with oil switches equipped with a trip device. As implied by their name, they serve purely as relays and must act in conjunction with contactors or switches.

Circuit breakers and overload relays may be arranged for instantaneous overload trip or a time element may be introduced, usually through use of a dashpot. The instantaneous trip feature protects best against short circuits, grounds and similar severe conditions, but will not always protect against sustained moderate overloads because it is usually necessary to set an instantaneous trip relay or circuit breaker rather high to prevent tripping on fluctuations or peaks of short duration. The time element feature enables a relay or breaker to be set at a value sufficiently low to protect a motor or line from injury due to sustained overloads, at the same time permitting short peaks without tripping. This feature is particularly desirable where fluctuating loads are involved. It is useful for overload protection of squirrel-cage induction motors, as the setting may be made such as to protect the motor while running, yet hold it during the brief peaks incident to starting.

In order to protect a direct-current motor fully, it is desirable to install fuses or other circuit opening devices in both positive and negative lines. If circuit breakers are used, they may best be made double-pole. If two trip coils are installed, one on each side of the line, the protection is quite complete. Where contactors are employed as circuit breakers, two overload relays or one double coil overload relay may well be used. Sometimes one relay is of the instant trip type, giving short circuit protection, while the other has a time element to afford overload protection. This is a good arrangement.

In the case of three-phase alternating-current motors, it is preferable to have a circuit opening device in all three-phase leads. This is particularly necessary if the neutral of the system is grounded. With an ungrounded system, two overload coils are necessary in two respective phase leads. On a grounded system, three overload trip coils are required to give complete protection.

TABLE V. CONDUIT SIZES FOR UNLIKE CABLES

SIZE OF CABLE B & S Gage	O.D. of R.C.D.B. Cable 600 V.in.	NO. OF CONDUCTORS FOR WIRE AREA													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
14	.250	.049	.098	.147	.196	.245	.294	.343	.392	.441	.490	.539	.588	.637	.686
12	.281	.062	.124	.186	.248	.350	.372	.434	.496	.558	.620	.682	.744	.816	.868
10	.312	.077	.154	.231	.308	.385	.462	.539	.616	.693	.770	.847	.924	1.001	1.078
8	.344	.093	.186	.279	.372	.465	.558	.651	.744	.837	.930	1.023	1.116	1.119	1.132
6	.437	.150	.300	.450	.600	.750	.900	1.050	1.200	1.350	1.500	1.650	1.800	1.950	2.100
5	.469	.173	.346	.519	.692	.865	1.038	1.211	1.384	1.557	1.730	1.903	2.076	2.249	2.422
4	.500	.196	.392	.588	.784	.980	1.056	1.372	1.568	1.764	1.960	2.156	2.352	2.548	2.744
3	.531	.222	.444	.666	.888	1.110	1.332	1.554	1.776	1.998	2.220	2.442	2.664	2.886	3.108
2	.594	.277	.554	.831	1.108	1.385	1.662	1.939	2.216	2.493	2.770	3.047	3.324	3.601	3.878
1	.656	.338	.676	1.014	1.352	1.690	2.028	2.366	2.704	3.042	3.380	3.718	4.056	4.394	4.732
0	.719	.406	.812	1.218	1.624	2.030	2.436	2.842	3.248	3.654	4.060	4.466	4.872	5.278	5.684
00	.750	.442	.884	1.326	1.768	2.210	2.652	3.094	3.536	3.978	4.420	4.862	5.304	5.746	6.188
000	.812	.518	1.036	1.554	2.072	2.590	3.108	3.626	4.144	4.662	5.180	5.698	6.216	6.734	7.252
0000	.875	.601	1.202	1.803	2.404	3.005	3.606	4.207	4.808	5.409	6.010	6.611	7.212	7.813	8.414
200,000 C.M.	.906	.645	1.290	1.935	2.580	3.225	3.870	4.515	5.160	5.805	6.450	7.095	7.740	8.385	9.030
250,000 C.M.	.937	.690	1.380	2.070	2.760	3.450	4.140	4.830	5.520	6.210	6.900	7.590	8.280	8.970	9.660
300,000 C.M.	1.000	.785	1.570	2.355	3.140	3.925	4.710	5.495	6.280	7.065	7.850	8.635	9.420	10.20	10.99
350,000 C.M.	1.062	.887	1.774	2.661	3.548	4.435	5.322	6.209	7.096	7.983	8.870	9.757	10.64	11.53	12.42
400,000 C.M.	1.094	.950	1.900	2.850	3.800	4.750	5.400	6.650	7.600	8.550	9.500	10.45	11.40	12.35	13.30
450,000 C.M.	1.156	1.049	2.098	3.147	4.196	5.240	6.414	7.343	8.392	9.441	10.49	11.54	12.59	13.64	14.69
500,000 C.M.	1.187	1.107	2.214	3.321	4.428	5.535	6.642	7.749	8.856	9.963	11.07	12.18	13.28	14.39	15.50
750,000 C.M.	1.375	1.485	2.970	4.455	5.940	7.425	8.910	10.39	11.88	13.36	14.85	16.33	17.87	19.30	20.79
1,000,000 C.M.	1.531	1.770	3.540	5.310	7.080	8.870	10.62	12.39	14.16	15.93	17.70	19.47	21.24	23.01	24.78

Area of Conduit Sq. in. .196	Size of Conduit in. 3/8
.307	½
.532	¾
.862	1
1.485	1¼
2.040	1½
3.341	2
4.784	2½
7.366	3
12.588	3½
16.209	4

No. of Conduit	% of inside Conduit Area
1	.56
2	.32
3	.42
4	.40
5 & over	.37

Example: What size of Conduit is required for 6#8 & 6#2 wires.

Area of 6#8 = .558 Sq.In.
Area of 6#2 =1.662 Sq.In.
.558 + 1.662 =2.220 Sq.In.
12 Wires would require an area not to exceed 37% of the area of conduit.

Area of above 12 wires = 2.220 Sq.In. which Divided by 0.37 gives the area of conduit required

$$\frac{2.22}{0.37} = 6 \text{ Square Inches.}$$

6 square inches takes 3 in. standard conduit.

EXPERIMENTS by the London General Omnibus Co., Ltd., on the use of a mixture of alcohol and benzol for motor fuel as reported by G. J. Shave to the Imperial Motor Transport Council, show that the best mixture is 50 per cent each of alcohol and benzol. Copper and iron are corroded by the mixture, hence tanks and pipes should be of brass or lined with lead or tin. Road runs showed that a larger per cent of benzol gave more miles per gallon, but also required more B.t.u. per mile. On the basis of the same cost per gallon for the 50 per cent mixture and for gasoline, the fuel cost per mile was slightly greater for the mixture.

Inlet valves and pockets became coated with a tarry substance, after six weeks running, but exhaust valves were clean and in good condition. There was no bad effect in the cylinders, and the engine was free from knocking and pre-ignition when running at low speeds and climbing hills. The engine started quickly, accelerated well and was flexible as to load and speed. On the whole, operation was satisfactory, and the tests seem to show that either the 50 per cent mixture, or a mixture of 65 per cent alcohol, 30 per cent benzol and 5 per cent ether can be used in place of gasoline without change of the power plant and at practically the same cost.

Protective Relays*

Their Application and Methods of Testing. By H. P. Sleeper

THE FUNCTION of a protective relay is to confine an electrical disturbance to the element in which it occurs, and to limit the amount of local trouble in so far as may be possible, usually by removing the applied potential. Almost any case of trouble on a transmission system or its connected apparatus can be handled by the proper application of modern current and directional relays using standard methods of connections. As the art of relay application is a rapidly advancing one, it is frequently interesting and profitable to review the modern up-to-date methods of protection which may be called standard.

System Protection

One of the most important applications of protective relays is to protect transmission systems. Here the particular duty of the relay is to disconnect a faulty section of line from the remainder of the system, thus preventing a general disturbance of the entire system and consequent loss of load. This is a most important application, for as all operating men will testify, their power customers complain most bitterly of any loss of power supply; with many consumers, even momentary failure of power means the loss of much time and money. Hence it becomes most important that systems be so laid out, and protective relays so applied, that no contingency short of a real emergency shall be able to cut off any station from its power source. It should be carefully noted, however, that the primary step in system protection is system design. No scheme of relay protection, however ingenious, can overcome the handicap imposed by an improperly laid out net-work.

The simplest scheme of system protection is that of a radial system as shown in Fig. 1. Here all lines radiate from the power source like the spokes of a wheel, and are sectionalized at various points, either for convenience in power distribution or for additional protection, as in the case of long lines. Current relays only are used and are applied to the transmitting end of each section to the power source, with increasing increments of time. By current relays are meant over-current, inverse time limit relays unless otherwise stated. No directional relays are used, for, since there are no parallel lines, nor interconnected stations, it is impossible to have a reversal of power flow. A fault at X in Fig. 1 will cause the current relay at station 1 to operate and disconnect the line 1-2 and hence remove the defective section from the system; however, as all stations fed from station 2 are also disconnected, this is not a satisfactory layout and hence is seldom used. As

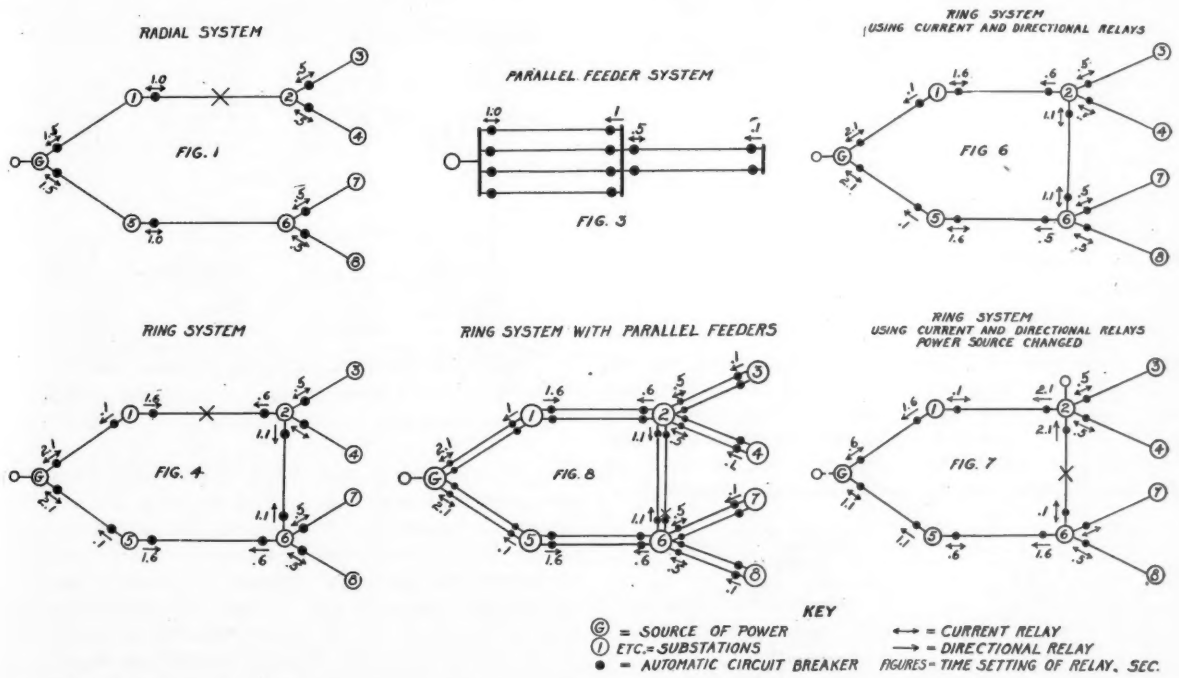


FIG. 1. SIMPLE SCHEME OF SYSTEM PROTECTION. FIG. 3. PARALLEL FEEDER SYSTEM. FIG. 4. SINGLE-LINE SYSTEM WITH INTERCONNECTED SUBSTATIONS. FIG. 6. RING SYSTEM USING CURRENT AND DIRECTIONAL RELAYS. FIG. 7. RING SYSTEM USING CURRENT AND DIRECTIONAL RELAYS—POWER SOURCE CHANGED. FIG. 8. RING SYSTEM, PARALLEL FEEDERS.

* From paper presented before the Meter Conference of the Ohio Electric Light Association.

individual radial feeders are found in every system, however, this scheme cannot be neglected. The connections for the current relays are shown below in Fig. 2.

The disadvantages of the radial system can be overcome by the use of parallel feeders, by interconnecting the substations, or by a combination of both.

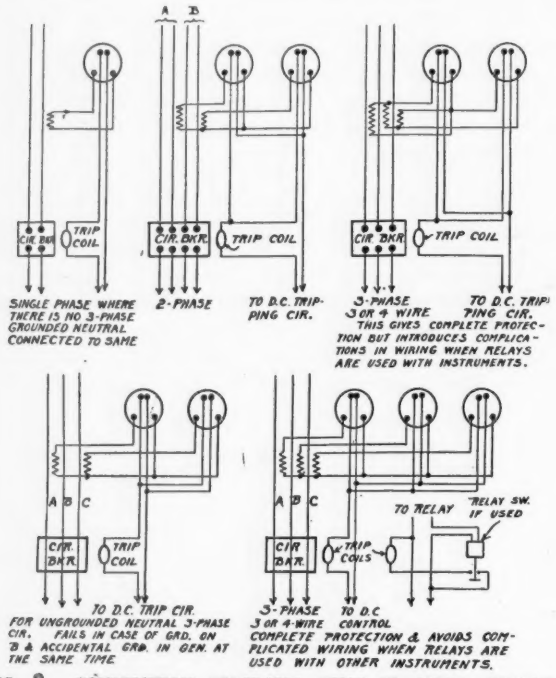

A B
CIR. BKR.
TRIP COIL
SINGLE PHASE WHERE THERE IS NO 3-PHASE GROUNDED NEUTRAL CONNECTED TO SAME
2-PHASE
TO D.C. TRIPPING CIR.
3-PHASE 3 OR 4 WIRE
THIS GIVES COMPLETE PROTECTION BUT INTRODUCES COMPLICATIONS IN WIRING WHEN RELAYS ARE USED WITH INSTRUMENTS.
A B C
TO RELAY
RELAY SW. IF USED
TO D.C. TRIP CIR.
FOR UNGROUNDED NEUTRAL 3-PHASE CIR. FAILS IN CASE OF GRD. ON B & ACCIDENTAL GRD. IN GEN. AT THE SAME TIME.
3-PHASE 3 OR 4-WIRE CONTROL
COMPLETE PROTECTION & AVOIDS COMPLICATED WIRING WHEN RELAYS ARE USED WITH OTHER INSTRUMENTS.

FIG. 2. CONNECTION DIAGRAMS, TIME ELEMENT, SINGLE-PHASE OVERLOAD RELAYS

A parallel system is shown in Fig. 3. Such feeders are protected by current relays at the transmitting end and directional relays at the receiving end of the line. In such a system, a fault on any line will draw reverse power from its parallel feeder and so instantaneously disconnect one end. The current relay on the other end will then operate and thus sectionalize the defective line.

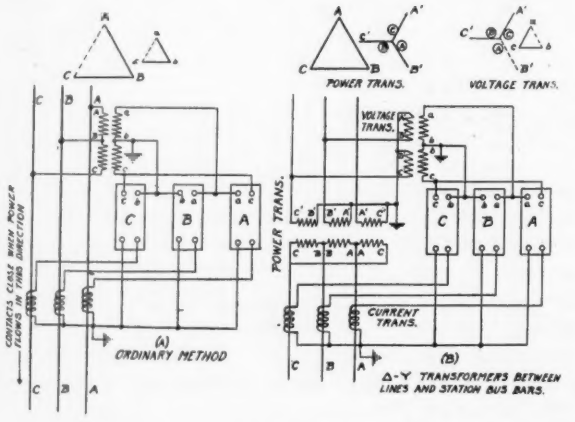

POWER TRANS.
VOLTAGE TRANS.
CONTACTS CLOSE WHEN POWER FLOWS IN THIS DIRECTION
(A) ORDINARY METHOD
(B) Δ-Y TRANSFORMERS BETWEEN LINES AND STATION BUS BARS.

FIG. 5. DIRECTION RELAY CONNECTIONS

The single line system with interconnected substations is shown in Fig. 4. This is the same system shown in Fig. 1, but with stations 2 and 6 interconnected. This type of system is ordinarily protected by applying directional relays, at both ends of all lines in the loop, except at the power station. As power can flow in either direction over any line in the loop, it is necessary to time the relays successively in both directions around the loop. If a fault occurs on this system at X, Fig. 4, the relay at station 2 will operate in 0.6 sec. and clear this end. The relay at station 1 will operate in 1.6 sec. and clear the other end of the line and thus remove the defective line from the loop. None of the other relays would have closed their contacts, owing to their selective time settings, and no station would have been cut off from its power supply. A diagram of connections for the directional relays is shown in Fig. 5.

It is interesting to note that as long as there is a power supply at station G, Fig. 4, the scheme of protection can be modified by using one set of current relays at each substation in place of the higher timed directional relays without affecting the scheme. This is desirable as it saves space, additional wiring and requires fewer potential transformers. This is shown in Fig. 6 which is the same system as shown in Fig. 4. This

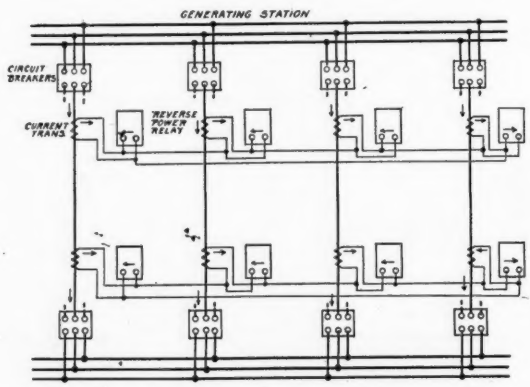


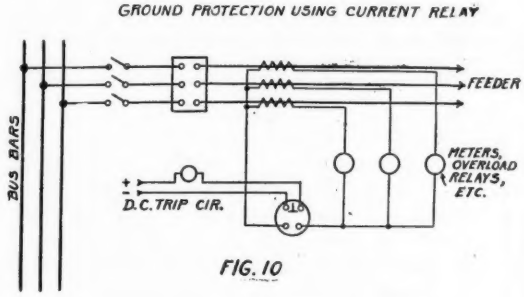
FIG. 9. CROSS-CONNECTED RELAYS SHOWING CURRENT TRANSFORMER CONNECTIONS FOR ONE PHASE

protection is equal to that of Fig. 4, where all substations use directional relays, as long as power is fed into the system at station G. If, however, the source fails at station G and is supplied by station 2, it is not possible to protect the system by changing the time settings on the various relays, in Fig. 7 where the same relays are used as in Fig. 6, but the times adjusted to receive the power fed in at station 2. Now a fault at X, Fig. 7, would operate the current relay at station 6 set at 0.1 sec. and also the current relay at station 1 set for 0.1 sec. and isolate every substation on the loop. Hence, if current relays are used on such a system in conjunction with directional relays, an accurate knowledge of the system is necessary to guarantee the safety of their application.

A modern system combines the parallel lines and the interconnected stations giving a network such as shown in Fig. 8. Such a system has the advantage of both these schemes and it is impossible for any station to become isolated unless both lines of the loop are open at the same point and a bus short or its equivalent is experienced.

It frequently happens, however, in the case of complex systems, that the relays on the two ends of one line

are timed the same. Referring to Fig. 8, it will be noted that the relays on the line between stations 2 and 6 are both set for 1.1 sec. If the loop had previously been opened between stations 5 and 6 and a fault were to occur at X, Fig. 8, close into the bus bars at station 6, the current in the lines at station 2 would be equal and in the tripping direction, and these relays would operate, together with the relay at station 6 on the faulty line, and thus completely isolate station 6. In such cases as this, it is customary to use cross-connected directional relays, connected as shown in Fig. 9. This relay automatically selects the faulty line and disconnects it when trouble occurs. The cross connection, however, finds its chief application on tie lines between generating stations, and on loops wherein the various stations are connected by parallel lines and power is fed in at more than one point. In such systems, it is very desirable that the various generating stations shall not become separated, due to the trouble which will be experienced when it is attempted to reunite the loop. The use of balanced relays is one of the most desirable means of securing discriminating protection under these circumstances. The cross-connection also finds an application on systems which are so complex that selective timing becomes impossible. The advantages of the cross-connection are (1) that it can be applied to any system having parallel feeders; (2) it is instantaneous in operation; (3) it can be made to operate on small unbalances of power, such as caused by high resistance grounds. Its chief disadvantages are (1) lack of bus bar protection; (2) trouble in cutting in new lines which may cause the lines already in service to be disconnected due to unbalanced power. Hence cross-connected relays offer disadvantages that are not encountered with standard connections but offer the solution of many difficult problems of protection.



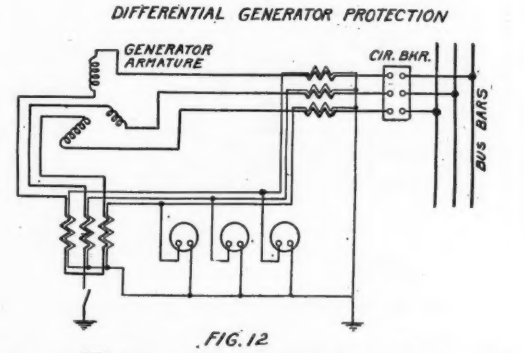


FIG. 10. GROUND PROTECTION USING CURRENT RELAY
FIG. 12. DIFFERENTIAL GENERATOR PROTECTION

Grounds

Ground protection of transmission lines is taken care of by the line relays on a system that is solidly grounded. If the system is ungrounded or grounded through a limiting resistance, it is then necessary to provide additional protection to take care of line grounds. This is ordinarily done by inserting a relay in the neutral connection of the line relays, which is operated by the unbalanced current which flows in the neutral wire when the line becomes grounded. This may be a current relay set to operate on a low value of current, as in the case of a system grounded through a low resistance. See Fig. 10. Or in case the system is grounded through a fairly high resistance, or is ungrounded, a watt relay is used, the potential coil of which is energized by the drop across a resistance inserted in the neutral of the potential transformers, as shown in Fig. 11. The current relay in Fig. 10 is set to trip at a low value of current, usually one ampere or less. The connections to the standard current relays are not affected nor is their operation. The relay has a time element and selective operation can be effected between successive sections of line. The watt relay in Fig. 11 is more sensitive to small currents in the neutral wire than is the current relay in Fig. 10, due to the presence of the potential coil. As this coil is energized by the drop of the ground current across the resistance, its flux is in phase with that of the current coil, consequently the

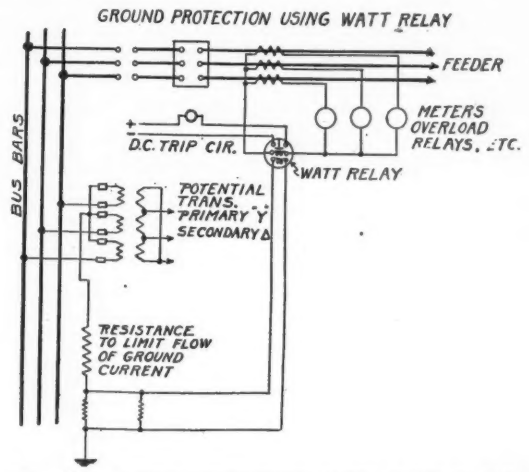


FIG. 11. GROUND PROTECTION USING WATT RELAY

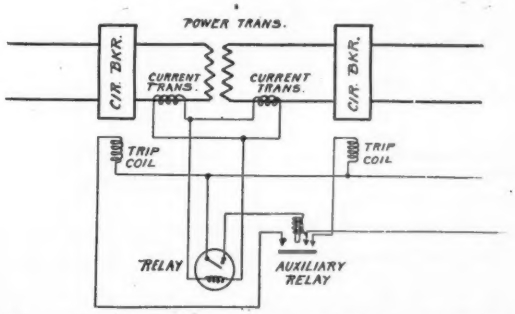


FIG. 13. DIFFERENTIAL RELAY ARRANGEMENT TO PROTECT TRANSFORMERS

relay has high torque. This relay also has an adjustable time element for selective action.

Generator Protection

Generators may be protected by current relays, directional relays, or differentially connected current relays, the choice depending upon the size and layout of the system and the design of the machines. Current

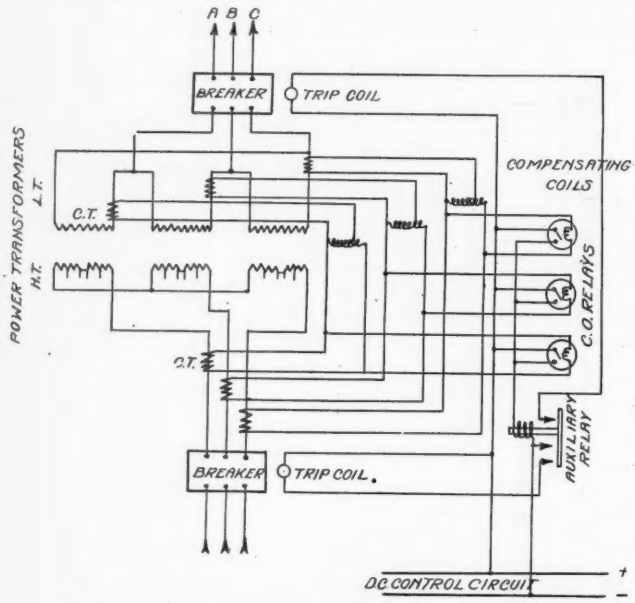


FIG. 14. DIFFERENTIAL TRANSFORMER PROTECTION

relays require too long a time setting and may permit excessive injury to a generator in case of an internal fault. Directional relays can be set for a shorter time, but may operate due to circulating current when synchronizing. Probably the most satisfactory method of

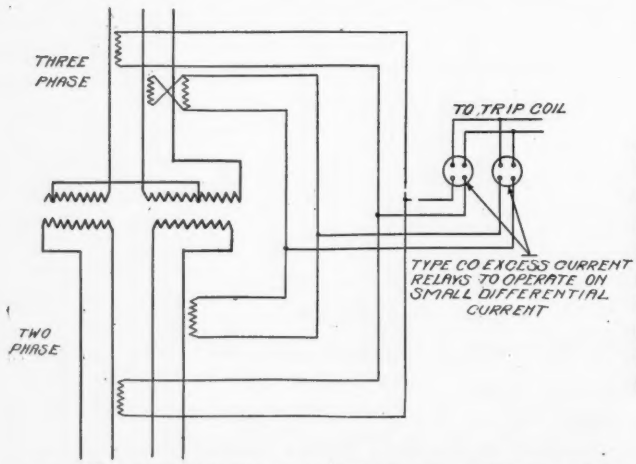


FIG. 15. DIFFERENTIAL TRANSFORMER PROTECTION USING STANDARD CURRENT RELAYS

protection, and the one most commonly used today, when possible, is that of differential protection. This requires that the neutral lead of each phase be brought out of the machine. A current transformer is connected on either side of each phase winding and the secondaries connected in series. The current relay is connected across the transformers, as shown in Fig. 12. Under all load conditions, the current circulates through the transformer secondaries and does not enter the winding of the high impedance relay. An internal fault, however, will cause the transformer nearer the busbars to draw a heavy current. The unbalanced current will flow through the relay and it will operate to remove the machine from the busbars. The relays can be set to operate instantaneously and hence this scheme gives maximum protection.

Transformer Protection

Power transformers are commonly protected by the same differential method of protection as described in connection with generators. See Fig. 13. Here the current transformer ratios are chosen so that the secondary currents are equal. Load conditions will affect both

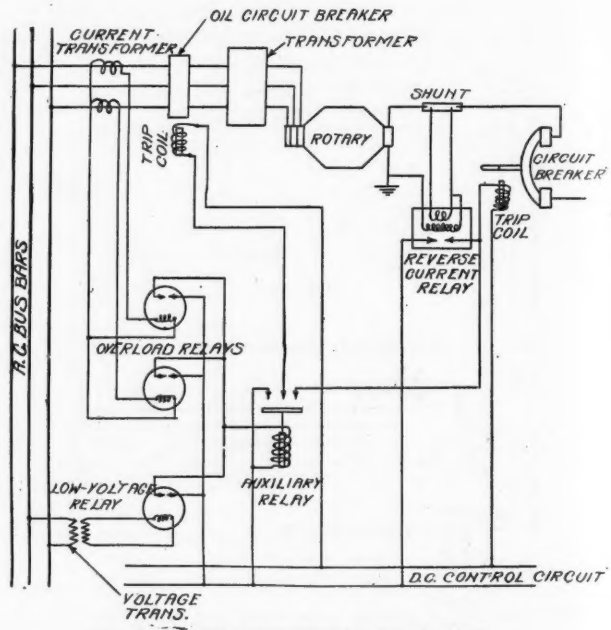


FIG. 16. RELAY PROTECTION OF ROTARIES

equally, hence no current will enter the relay. When trouble develops in the windings, however, the unbalanced current will operate the relay and disconnect the power transformer from the line. The scheme can be applied to transformer banks which are connected star-star, delta-delta, delta-star, star-delta, or two-phase, three-phase. See Figs. 14 and 15. It is only necessary so to connect the current transformers that the resulting opposing currents are equal in value and 180 deg. apart in phase.

Rotary Converter Protection

Rotary converters are ordinarily protected by means of current and low voltage relays on the a.c. side, reverse current relays on the d.c. side, and an overspeed device. See Fig. 16. The current relay performs its usual function. The low voltage relay takes the rotary off the line in case of failure of the a.c. potential and thus prevents motoring from the d.c. side, as does the d.c. reverse current relay in case of current reversal.

The overspeed device on the armature is an ultimate protection in case of failure of the relays.

Synchronous Condensers

The proper method of protecting synchronous condensers is a question on which opinions vary. The operating conditions of this machine are peculiar in that it is desirable to keep this machine on the line under all system conditions, and yet be able to protect the condenser

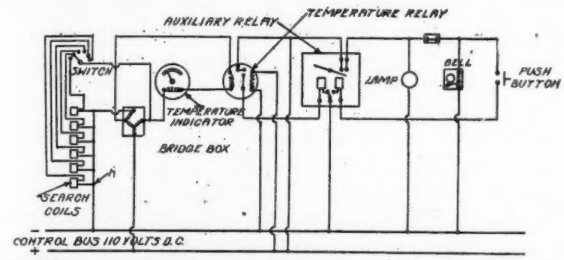


FIG. 17. TEMPERATURE INDICATING AND ALARM EQUIPMENT

from internal faults. The condenser must also be protected from severe overloads and yet must be capable of carrying a high overload for short periods of time or until overheated. Hence protection can be best secured by a combination of current and temperature relays. The current relay is frequently set for a long time on overloads of the nature of 200 to 400 per cent but provided with an instantaneous attachment which will operate on 500 per cent load. Thus the line relays will remove defective feeders from the busbars before the long-time relay on the condenser can operate. But in the case of a short circuit in the condenser or on its leads the instantaneous attachment will operate to protect the condenser. The temperature relay, which is controlled by exploring coils in the stator slots, allows the machine to carry a reasonable overload for a considerable length of time until the temperature of the machine has reached a dangerous volume. It then operates to warn the operator by means of an alarm, or it automatically operates the voltage regulator on the system to relieve the condenser. See Fig. 17.

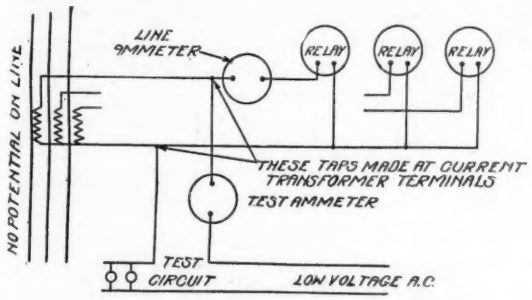


FIG. 18

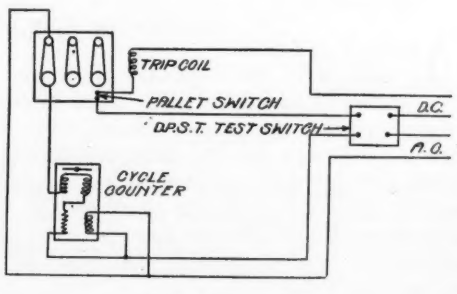


FIG. 21

FIG. 18. CONNECTIONS FOR TESTING RELAYS IN SERVICE
FIG. 21. TIMING CIRCUIT BREAKER OPENING

Testing

The importance of thorough and frequent testing and inspection of protective relays cannot be overemphasized. The relay is a vital part of a system and upon its proper operation depends the safety of a considerable financial investment, as well as the integrity of that present-day by-word "continuity of service." The methods and schedule of these tests vary with the

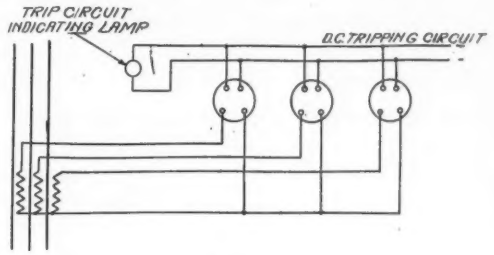


FIG. 19

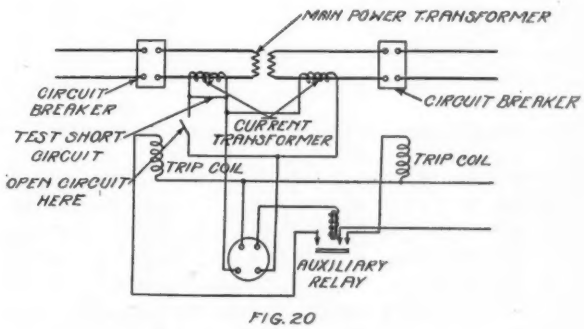


FIG. 20

FIG. 19. LAMP FOR TRIP CIRCUIT INDICATION
FIG. 20. CONNECTIONS FOR TESTING BALANCED RELAYS

different operating companies but as the problem is a common one a few general recommendations can be made.

The frequency of making these tests is largely a matter of personal opinion, operating conditions, and available resources. For instance, a relay which operates frequently should be inspected more often than one which is called upon to operate only at rare intervals. Likewise a relay which is located in a dust-laden or gas-filled atmosphere is in need of more attention than one situated under more favorable conditions. In general, however, a thorough test of every relay should be made at least twice a year. This test should include calibration and insulation tests.

The ideal method of calibrating a relay and testing all connections at the same time is to apply load to the current transformer primary. This tests all circuits and

connected units. As this method is usually impractical, however, it is customary to use the method shown in Fig. 18. This does not disturb any wiring whatever and tests the continuity of all circuits and the condition of the current transformer secondary. Some type of automatic chronometer such as a cycle counter should always be used to check the time curve, as a stop watch is entirely inadequate.

Even more important than the semi-yearly tests, however, are the frequent inspection tests which are made at regular intervals. It is these tests that bring to light the ordinary ills of relays. Such tests are made by some operating companies as often as once a week, the average being about once a month. In making these tests special attention should be placed on the removal of dirt, cleaning and alining of contacts, and the proper operating condition of the moving element. This last is particularly important, especially in the case of induction relays which have a disk rotating in the small air gap of a permanent magnet. Blowing out these relays may cause magnetic dirt to lodge in the air gap and

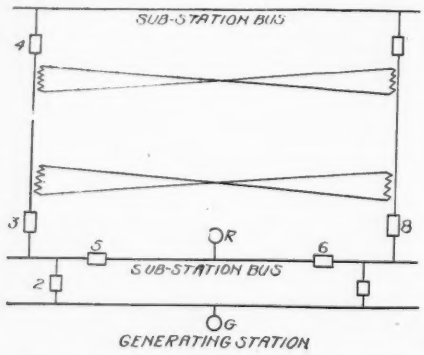


FIG. 22. RELAY TEST SIMULATING SHORT CIRCUIT

destroy the calibration of the relay. This can be removed by a piece of iron wire. The condition of the trip circuit should be checked by manually operating the relay contacts. As this is a very important matter, it is the custom of many companies to make the checking of this circuit a matter of daily routine. Thus once during the day, at a time when the line is to be removed from service, or when it can be taken out without disturbing the system, the operator will open up the relay and close the contacts by hand. This tests all parts of the tripping circuit. Some companies consider the point so important that they provide a permanent indication of the integrity of the tripping circuit by connecting a lamp permanently across the relay contacts. As long as the lamp is lit, the operator knows that the tripping circuit is intact. When the relay is operated, the contacts short-circuit the lamp and the additional current in the trip coil is sufficient to cause it to operate. See Fig. 19.

Frequent cases of trouble on directional relays are traceable to wrong voltage connections resulting in a wrong phase angle between the current and voltage fluxes in the relay. This matter can be simply checked, and should always be checked when relays are first installed, by applying a single-phase wattmeter in the relay circuit. At 100 per cent power factor on the line, the current in the relay should lead the voltage by 30 deg. This can be read directly on the power factor meter and the proper voltage leads chosen. Or the same result can be obtained by choosing the pair of voltage leads which gives a maximum reading on the single-phase wattmeter, when the load power factor is lagging.

The complete connections of any balanced system of relay protection can be tested very simply by short-circuiting the secondary of either one of any pair of balanced current transformers, and opening the line outside of the short circuit. This produces a severe unbalance and the unbalanced current operates the relay and trips the breaker, thus testing all related circuits. This should be repeated by successively short-circuiting the secondary of each of the current transformers. For connections, see Fig. 20.

The timing of the opening of circuit breakers should also be periodically checked. The proper adjustment of a circuit breaker to cause it to open in a predetermined time is a matter of importance both for the protection of the breaker itself and for the proper co-operation of its action with that of the relay which actuates it. This is particularly true on a system where the relays are set with minimum allowable differences in time setting. Connections for the test are shown in Fig. 21.

Some operating companies prefer to test the operation of their relays by duplicating actual service conditions. This is done either by imposing an actual short circuit on the system, or else by simulating short circuit conditions by the manipulation of connected apparatus. This can be very conveniently done when the apparatus is connected as shown in Fig. 22. Switches 2 and 6 are opened and the power is fed from the generator around the loop in a counter clockwise direction to the rotary R. Breakers 3 and 4 would come out as their power flow is reversed with reference to the other line with which it is balanced. The other line is similarly tested by opening switches 5 and 1 and feeding the rotary R through the loop in a clockwise direction, tripping breakers 7 and 8.

Experiences at Glendale

THE HUMAN PROBLEMS PROVE MOST IMPORTANT. BY G. H. KIMBALL

Glendale, July 1, 1920.

DEAR WALLACE:

Not much has happened since you were here so two of your letters have come through without an answer from me. As you know, Gillis commenced here in May and the day that he commenced work, Gooch recognized him and most of the first day was spent by him in listening to all of the things that had happened to Gooch and how there were so many circumstances that were extenuating that really nothing could be laid to his door.

Gooch said that he needed a man like Gillis and he could have got one sooner if Wallace had not been trying to get back on the job and could not do it. That sounds rich after the offer that you had from Wilbur.

Gillis has had his hands full all right and he commenced by going over the 400-hp. steam engine and after considerable work got her so that she would work fairly well. The valve gear on that machine seems to be a hard thing to adjust, for some of the would-be

engineers that have tried it have certainly had a circus. Do you remember that day in December three years back when the low pressure wristplate broke and the day that it came back from the factory and there was a heavy snow falling? I was glad that I did not have charge of the plant that day, for it looked as if we could not run the cars for one while before we got the steam engine on. There we had plenty of alternating current available, but it was of no help for the railway load which used direct current. I was glad when you finally got her on the line and I bet the men on the cars were too.

There has been much to do on the oil engine and the crank case was in awful shape, so he cleaned it all out and put in new oil and then he tried out the fuel valves and, of course, they needed adjusting badly. I don't think that Gooch with all of his experience around oil engines knew how to set these valves and he was of no use to Gillis. The exhaust valves were in bad shape and they set to work to grind them, then with some adjustments on the crank and wrist boxes they improved the machine remarkably. She will never run as in former days, though, for she has been abused too much.

Gillis and Gooch got into an argument the other day and at the conclusion of the talk Gillis said that he had better go up and see the manager and he departed for regions unknown. The company evidently has some plans for the future, for Gillis told me today that Wilbur plans to put in another oil unit as soon as possible and that in about a year they will take out these three steam engines and put in one larger than all of them combined. When that is done, they should have plenty of reserve power.

Gillis has hired Bill Henry who used to work for you to run the afternoon shift and he should be of great help to us. Oh! by the way, we have gone on to eight-hour shifts now and it will be much easier to get men to work here from this time on. They have talked about it for many years and finally it is put into effect.

Things look the best of any time since you left and I hope we have seen the end of foolishness in this plant. Just as I was about to seal this up, Gillis came in and said that Wilbur had heard that you were going to leave Bridgetown and of course I am greatly interested to hear all about it. Please let me hear from you as soon as you get time to write.

Your friend,
JOHN BLAKE.

Bridgetown, July 10, 1920.

DEAR JOHN:

I can imagine the job that Gillis has before him and if he once gets the valves set on that 400-horse steam engine, he will do well to leave them alone, for it sure is a queer machine to adjust. I have seen some pretty good men get balled up on the job and when some of the wouldbes that you have had with you take a hand in setting the valves, the result is not hard to imagine. As you know, both sets of steam and both sets of exhaust valves are moved by the same eccentric and any change of the eccentric is made effective in both cylinders so the release and compression must be set to act equally at each end of the high and low pressure cylinders and then any minor change can be made with the adjustable links. At the time you refer to the exhaust wristplate breaking, the back link on the low-pressure cylinder seemed to be too short and it would pull the exhaust valve crank almost to point where it was in the same position that an engine crank is when on the center. When it reached the center position, something had to break and the wristplate let go.

How that link came to be so short I cannot tell, unless someone shortened it and if I remember rightly, the tram marks were all right. When we had put the new wristplate on and started up the engine, I thought that I would just try it out slowly and after she got going fast enough she commenced to pound badly on that valve and I stopped her and lengthened out the link and then as the cars needed her help badly you will recall that we took off the back bonnet and with the engine on center we found that the two valves were set very differently, so I placed them alike and found that she would run all right and we let her take some of the load until after supper and bring up the battery which had run down badly during the storm. Later, we got the valves in pretty fair shape by using the indicator.

Bill Henry will make Gillis a good man if he has gotten over that dissatisfied attitude that he used to affect. When he first worked there, I thought he was going to be an excellent man for us; but he got to the point where he was of no use to himself or anybody else, so we had to let him go. I can remember telling him when he came there that he might be in line to have charge sometime, but I suppose that he thought that I would be there for the rest of my life and there was no chance; yet in less than three years I was on my way down here and if he had held out a little longer, he would have been a good man to carry on the work. I think that he has profited by the experience by this time.

About my leaving here, you have heard rightly and after the year and two months that I have put in in this place I think that it is just as well. The officials say that they are reluctant to have me leave and I am sure that they would make the salary all right, but that is not all, and the way in which we have to operate these engines and with no chance to repair them, shows that something will have to happen in time. I came here with the highest hopes that this would be a place where I should wish to stay for a term of years, for it is a great plant taken as a whole and should make a fine job for every man connected with it; but there is too much favoritism here and it is shown on every honest man who comes here to work. They cannot say much to me, for I am the only one who can operate these engines; however, I cannot see that there is much of a future here, so I am finishing up next Saturday. You will be interested to know that I expect to go to the Union Terminal power plant in the city of Holton where I shall be an assistant for the first time in six years. The chief seems to be a pretty good old man and I am ready to let somebody else have the main responsibility for the plant for a time. This is quite a plant, with five engines, an air compressor, two turbines and nine boilers and is located in a very busy place. I am going to try it, although it may be a mistake. So my next letter will be after I have commenced work at the Union Terminal plant.

Yours very truly,
WILLIAM WALLACE.

Tilting Trap Troubles

TROUBLES ENCOUNTERED IN THE OPERATION OF TILTING TRAPS AND THEIR REMEDIES. BY H. A. JAHNKE

ON MOST tilting traps all mechanism is visible and accessible, but still this type of trap is liable to give trouble at times which is not easy to locate, especially where the man in charge has had but little experience with them. It is the writer's intention to relate some of the troubles he had with them and how these troubles were remedied.

I use a direct tilting trap for boiler feeding; this trap is located in a compartment above the boiler room. One day I noticed that the trap would not furnish sufficient water to the boilers although the steam and water valves were open as usual. This puzzled me for some time until I noticed that it took much longer than usual for the trap tank to fill with water. At first I thought the water in the water supply pipe was low, but this was not the case. In the meantime, however, the water was becoming lower in the boilers so I had to shut down the trap and start the spare pump.

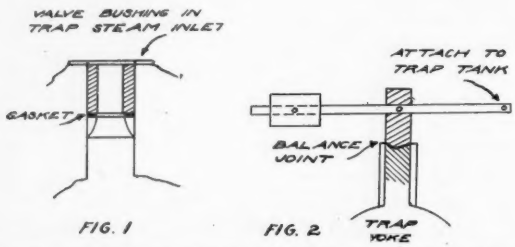


FIG. 1. SKETCH SHOWING LOCATION OF VALVE BUSHING AND LOCATION OF GASKET

FIG. 2. SHOWING UNEQUAL WEAR ON BALANCE JOINT

I then examined all parts of the trap and found that part of the gasket under the steam valve bushing had blown out. Type of valve bushing and location of gasket is shown in Fig. 1. This leak allowed steam to blow into the trap tank although the steam valve was closed and, as a consequence, would not allow the pressure in the tank to go much below that of the water pressure. This was the reason why the trap tank would not fill as quickly as before; a new gasket below the valve bushing quickly cured the trouble.

BALANCE JOINT WORN

AT ANOTHER time, I could not adjust the balance weight so the trap tank would move up or down when tank was empty or full. The tank would either stay in the filling position or dumping position. No adjustment of the balance weight would remedy the trouble although all packings were renewed and adjusted, all joints thoroughly oiled, and I was sure there was no binding anywhere. One day, however, I noticed that the balance weight and arm hung to one side of the tank where previously it hung about in the middle of the tank. At first I thought that the trap had settled on one side causing the balance weight and arm to lean to one side, but upon testing with a level this proved not to be the case. In looking further for the trouble I discovered that the balance joint, as shown in Fig. 2, was worn more on one side than the other, which allowed the weight and arm to drop to one side, causing the joint to bind. Consequently I could not adjust the weight so that the trap tank would operate up and down freely as before.

EXHAUST VALVE NEEDED ADJUSTING

IN ANOTHER instance, when I noticed that the trap did not furnish sufficient water to the boilers, I assumed that the gasket under the valve bushing had blown out again. This, however, was not the trouble this time, and, later on, I discovered that the exhaust or vent valve needed adjusting, as one of the valve rod adjusting nuts had worked loose and did not allow the exhaust valve to open as quickly and wide as before. This prevented the pressure in the trap tank from being relieved rapidly enough to allow the tank to fill with water. Hence the slow operation of the trap. When the valve was properly adjusted the trap furnished sufficient water to the boilers once more.

CHECK VALVES LEAKING IN FEED LINE

IN STILL another instance, the trap tank would not fill with water although the water supply valve was wide open. I knew the steam and exhaust valves were in good

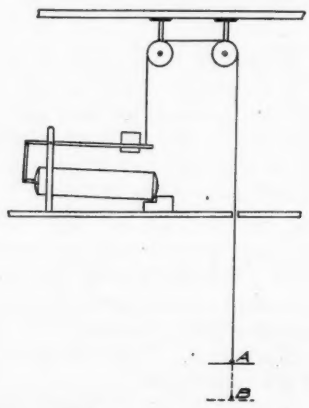


FIG. 3. ARRANGEMENT OF ROPE FOR OPERATING TRAP IN CASE OF EMERGENCY

working condition and also that there was sufficient water pressure in the line. Why would the tank not fill? In thinking the matter over I decided to examine the check valves in the feed line to see if they leaked. After closing the valve vent to the boiler I removed the bonnet on the check valve vent to the trap and found that the disc was cut badly. A new disc was installed which remedied the trouble and the check in the feed line vent to the boiler was repaired at the next cleaning of the boiler.

OPERATING TRAP TEMPORARILY WITH ROPE

ONE DAY I found that the trap would not operate properly; it would either remain in the filling or dump-

ing position and no adjusting of the balance weight would remedy the trouble. I was unable to locate the cause, since I could not shut down the trap to examine it thoroughly and as the trap is located in a room above the boiler room it was very inconvenient to climb up the ladder to make the trap operate whenever it failed to operate. To overcome this trouble I had the fireman attach a rope to the weight lever and by passing this rope over small pulleys located near the ceiling and down through the boiler room ceiling so as to be within easy reach from the boiler room floor we could tell at a glance whether the trap was operating or not. Whenever the tank would stick, a little jerk on the rope would loosen it. In this way we kept the trap going until we secured opportunity to examine it. The arrangement of the rope and trap is shown in Fig. 3. When the trap was repaired the rope was not removed but left in position so we could see at any time whether the trap was operating or not by noting the condition of the rope. When the end of rope is at b the trap tank is in the dumping position, when at a in the filling position. Should the rope remain in one position too long we know that the trap is not operating as it should.

Kink in Relieving Pressure in Tank Quickly

The exhaust or vent from our trap discharges into the hot water tanks and, at times, when the steam valve leaked it would prevent the trap tank from filling as quickly as it should. To overcome this trouble I arranged the exhaust pipe from the trap in the following manner. There is a check valve in the pipe line between trap and tank as shown in Fig. 4. I removed the bonnet from this check, drilled and tapped this and fitted a ⅜-in. pipe with a valve in it leading into the tank as shown in Fig.

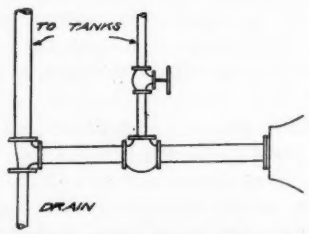


FIG. 4. PIPE CONNECTIONS FOR QUICKLY RELIEVING TANK PRESSURE

4. After this, should the trap tank not fill quickly due to back pressure in the tank and I am certain that the steam valve is leaking, causing this back pressure, the valve in the ⅜-in. line is opened, which relieves the pressure in the tank quickly. The valve is left open until there is an opportunity to regrind the trap steam valve.

Water Regulating Valve Stem Was Disconnected

As our trap is located in a room above the boilers, to regulate the water to the trap a lever gate valve is used which is operated by means of a rope fastened to the lever of the valve, then down to the boiler within easy reach of the fireman. By means of this rope the valve is opened the required distance while a spring is attached to the valve lever and floor, which closes the valve. One day the fireman reported that the trap would not operate with the water valve wide open and in looking for the trouble I found that no water was going to the trap although the lever of the gate valve was up. This was puzzling to me and upon opening the drain valve at the bottom of strainer I found no water there. I next opened the strainer as I thought perhaps this was clogged up, but I found it clear. I then examined the gate valve and in looking at the lever and stem I noticed that the lever was disconnected from the stem, due to the fact that the nut had come off the connecting bolt. This, of course, allowed the valve to stay closed with the valve lever in an open position. Placing the bolt in position remedied the trouble and after having this experience I placed a longer bolt through the lever and stem thus making it possible to add a lock nut. With this addition the bolt could not work out again and further trouble was prevented.

A Suggestion

In some plants where tilting traps are used for boiler feeding and returning condensation from the heating system to the boiler, the exhaust from these traps dis-

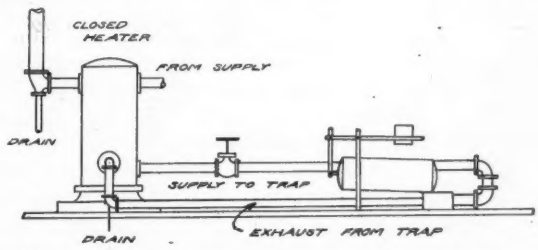


FIG. 5. SUGGESTED ARRANGEMENT FOR UTILIZING EXHAUST FROM TRAPS

charges into the ash pit or atmosphere, while the trap feeding the boiler receives cold water. It is a much better plan to discharge the exhaust steam from these traps into a heater, thereby utilizing the heat in this exhaust steam by heating the feed water. This would make the water which the trap discharges a higher temperature, thereby reducing the fuel expense. It would be a simple matter to arrange the trap, piping and heater as shown in Fig. 5 to obtain the desired results.

In this arrangement, the trap exhausts into a closed heater, which receives water from the city mains. The water to the trap is regulated by the valve shown.

I used to return all condensation from the heating system to the boilers by means of a duplex steam pump attached to a receiver. Some time ago, however, I decided to use a lifting trap for this purpose as the pump was almost worn out; so the old pump was disconnected from the receiver together with all automatic parts which were used on and in the receiver to operate the pump. All holes were closed up except the inlet and outlet connections for the condensate. The trap then was placed in position and connected to the outlet of the receiver. In this way the price of a new receiver was saved, also much labor and fittings had the old receiver been torn out and a new one put in its place. The lifting trap now discharges to the boiler feeding trap. This illustrates the fact that an engineer has the opportunity in many instances to reduce expense by doing a little thinking and sketching before ordering new apparatus.

A Few Points on the Care of Tilting Traps

When repacking the trunnion joints on a tilting trap or drawing up or loosening the packing glands the trap should be watched for a while afterwards to see that it operates properly as in loosening or tightening the packing glands more or less friction is placed at the trunnion joints, hence the counter-balance weight must be shifted forward or backward on the weight lever.

The packing at the trunnion joints should not be allowed to leak very long as this will allow scale to accumulate between the packing and trunnion which results not only in cutting but causes irregular friction at the trunnion joints, making it necessary to readjust the balance weight frequently. To avoid this trouble the packing should be renewed before it becomes too hard.

Some types of tilting traps are equipped with a dash-pot at the front of the trap tank for the purpose of lessening the blow due to the tank striking the top and bottom of the yoke beween which it is located, when filling or dumping. This dash-pot must always be kept full of oil and adjusted so it will form a cushion when the trap tank comes near the top or bottom of the yoke.

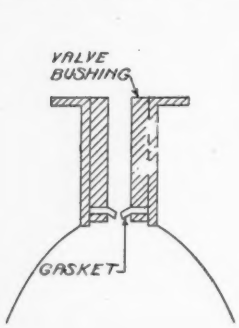


FIG. 6

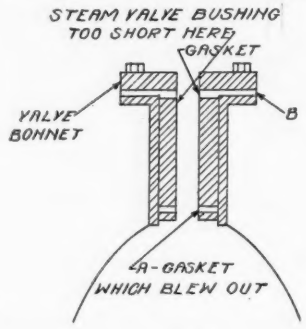


FIG. 7

FIG. 6. LOCATION OF GASKET WHICH CAUSED TROUBLE
FIG. 7. SHORT BUSHING REQUIRED THICKER GASKET

When I installed my traps I did not pay much attention to the dash-pots to see that they always were in good working condition but after a short time I noticed that the tank showed signs of wearing at the point where it comes in contact with the yoke. After this I gave more attention to the dash-pots.

Where tilting traps are in use for boiler feeding the check valves near the trap and boiler must not leak and they always must be kept in good condition. Even if they leak just a little the trap will not operate properly since the pressure in the trap tank will build up, allowing no water to enter, and one is apt to think there is something wrong with the trap.

I use extra heavy swing check valves on my feed lines which are of the removable disc type. These valves are examined at each boiler cleaning and repairs made wherever necessary. As there are a number of bearings on a tilting trap it must be remembered that they need oiling the same as any other machine or else in the course of time these joints will be worn so badly that they must be replaced, hence oil them frequently.

As some of these bearings get quite hot from the heat of the trap, plain machine oil will not remain very long and I find that steam cylinder oil does the work much better.

A Peculiar Tilting Trap Trouble

Not long ago it was necessary to place a new gasket under the steam valve bushing in a tilting trap used for returning the condensate from the heating system back to the boiler. A few days after placing the gasket it was noticed that whenever the trap tilted into the dumping position it would take some time before the steam would pass through the steam valve into the trap tank in order to force out the water. At first I thought that perhaps the steam valve would stick, due to some shoulder having formed in the valve bushing, or that the valve stem packing was drawn up too tight. After examining these parts I found this was not the trouble.

At the first opportunity the steam valve and bushing were removed. I found that the new gasket placed under the valve bushing caused all the trouble and was done in the following way: The gasket used under the valve bushing is supposed to be a hard gasket, asbestos or some similar material, which will not give or squeeze out when pressure is applied on it. In this particular instance we had no gasket of this type on hand, so a gasket of rubber was used under the valve bushing, then after screwing down on the valve bonnet the gasket, being soft, spread out, thereby partly closing up the steam passage in the steam valve; then, when steam was turned into the trap, the gasket expanded still more, closing the valve opening still more, as shown in Fig. 6. When the soft gasket was removed and replaced by a hard gasket which did not spread there was no further trouble.

Heavier Gasket Caused This Trouble

In another instance, while replacing a worn-out steam valve and valve bushing in a tilting trap, it was found that the gasket under the new valve bushing would blow out too frequently. There seemed to be no reason for this, as the same type and thickness of gasket was used under the new bushing as under the old bushing.

One day, when the gasket blew out again, I removed the valve and bushing from the trap. In examining the gaskets A and B as shown in Fig. 7, I noticed that the gasket A under the valve bushing was compressed very little, although the bonnet cap screws were turned as far as was possible. Then I thought that the new bushing must be a little shorter than the old bushing, hence the lower gasket would not be compressed as much as it should be in order to hold it. In measuring the new and the old bushing. I found that the new bushing was 1/32 in. shorter than the old one and all that was necessary was a thicker gasket at A so that it would compress more when drawing up on the valve bonnet cap screws.

The Miracle

Efficiency Engineer: "On an average, how much vacuum do you realize with your present equipment?"

Important Oiler (who has been mistaken for engineer): "Well, I can't just say. You see, our gage is busted; but I should judge that we average about 45 in."

Which goes to prove that the age of miracles is not yet a thing of the past.

Refrigerating Engineers Meet

ELEVENTH ANNUAL CONVENTION OF THE N.A.P.R.E. IN CHICAGO FROM DEC. 13 TO 16

ASIDE from the question of election of officers and the transaction of routine business, the object of the convention of the National Association of Practical Refrigerating Engineers was of an educational nature. Papers were presented on various topics of interest to the members.

Joseph Hays opened the educational program with an address on "Combustion." He covered briefly the elementary considerations involved in the study of combustion and the use of instruments in the regulation of firing. It was pointed out that complicated systems of indicating and recording instruments are of little or no value unless the results are carefully analyzed with a view of correcting poor conditions. In the discussion, the question of proper height of bridge wall, height of setting and baffling were brought up.

Mr. Hays recommended that, for horizontal return tubular boilers, the bridge wall be built up to and fitted around the boiler shell, leaving a port about a foot or so below the shell to allow the gases to pass out. The object of this arrangement is to prevent the flame from licking the cold boiler surface which arrests the combustion. In closing, he said that no fixed rules could be set down for every installation because each case was a problem in itself and must be solved from fundamental principles.

Powdered Coal was the subject of the paper read next by Milton W. Arrowood. He covered, more or less completely, the applications in various industries, methods of manufacture and firing. He emphasized the necessity of providing a large enough combustion space in order to give each particle of coal time to burn completely before reaching the boiler heating surfaces, and as an aid in accomplishing this result, the importance of thoroughly mixing the coal and air before they enter the combustion chamber. He called attention also to what he termed the fallacy of the high velocity blast method of feeding which, beside the blow torch action on the brick work, allows stratification of air and coal. Coal requires about 8000 times its volume of air for combustion so that each cubic inch of air should contain about 1000 particles of 200 mesh coal. Mr. Arrowood also stated that a plant using 25 t. of coal per day was about the minimum size that could economically pulverize its own coal. It was suggested that ice plants could profitably take up the manufacture of pulverized coal for the numerous small plants under this minimum capacity.

George H. Trout addressed the assembly on the subject, Gas Power for Ice Making and Refrigerating Machines. He went over in a general way the principles involved and the fields of endeavor to which this kind of power could be applied.

J. D. Harper started things Tuesday morning with an address on Oil Engines as applied to Refrigerating Machinery. In considering the kind of power best adapted to refrigerating and ice-making plants, each case must be decided for itself on its own merits. In the days when distilled water was used exclusively for the manufacture of ice, steam was thought to be the only possible source of power, but since the advent of raw water ice other sources have been introduced.

The location of the plant should be a determining factor just as with power plants. A plant, for instance, conveniently located in an oil field would do well to use oil and a plant so situated as to be able to obtain electric current at a low cost should investigate the possibilities of electric drive.

Oil engines have been thought to be too delicate a piece of apparatus for ordinary use in a plant, but such engines have been developed to such a point that endurance records compare favorably with other systems. Reliability is an important factor which has been attained by the oil engine.

Where units of more than 400 hp. are required, Diesel engines are recommended, due to their higher efficiency at this rating; but for anything under this requirement Mr. Harper suggests the surface combustion type, two-cycle, valveless, rugged in construction, which eliminates all valve appurtenances and utilizes ordinary fuel oil. This engine operates on the fuel injection principle with 300 lb. compression pressure. The fuel consumption of these engines is 0.48 lb. oil per horsepower-hour for sizes under 35 hp. and 0.45 for larger sizes, which figures at present prices from 0.4 to 0.5 cents per hp.-hr. Electric power to compete with this would have to be bought for ¾ cent per kw.-hr. or less. As a citation of the reality of these engines, Mr. Harper mentioned some installations where they have run from 50 to 250 days without a stop.

A paper on the Uniflow Steam Engine was read by Robert Cramer in which he took up from an elementary point of view the principles of operation and the construction. The principal advantage of this type of engine is the good steam economy effected in small sized units. The steam consumption curve is unusually flat, showing good economy over a large range of ratings. The water rates range from about 10 lb. with 200 lb. pressure, 100 deg. superheat, and 27 in. vacuum to 23 lb. per b.hp. per hr., depending on the size. Compound engines show water rates of this order, but only for one particular load. Any slight variation from this point either over or under will show a marked increase. This engine is able to effect these economies because of the reduction in cylinder condensation. A prime essential in making this reduction is that the head must be steam jacketed.

Following this there was a paper by Thomas C. McKee on High Speed Compressors in which he followed the development of this machine and the factors which made it possible. Chief among these was the feather valve which is able to function much more quickly than the old type valve. The moving parts of a 6-in. feather valve weigh only 6 oz. and the lift is ¼ in. This valve consists essentially of a grid upon which are fitted strips of spring steel which are held in contact with the seat at their ends. Pressure in the cylinder lifts these strips at the middle, which allows

the gases to escape. On the back stroke these strips slide back on the seat without shock. An advantage of this valve is that it will handle slop-overs, making the false head unnecessary. More clearance is required in the cylinder with this valve but the same efficiency can be maintained by simply speeding up the machine one or two r.p.m. to make up for the loss.

The Present Status of the Two-Stage Ammonia Compressor was next discussed by Harry Sloan. He reviewed in general the development of two-stage compressors, air as well as ammonia. It was the use of booster units for low temperature work that finally assured the success of this type of machine. Some actual figures on economy of operation were given, showing a 15 per cent saving by compounding and a steam rate of 24 lb. per ton of refrigerating effect. It was also brought out that a zero clearance was not essential, a 4 or 5 per cent clearance could be employed with only a slight drop in volumetric efficiency. He also made mention of the increase in efficiency obtained by intercooling with liquid ammonia.

In a paper, Increase in Capacity of Ice Machines by the Application of the Multiple Effect Compressor, H. T. Whyte explained the savings that had been made at the plants with which he is connected by installing this device on their compressors. The device is simply a valve mechanism whereby gases at two different pressures can be admitted to the cylinder, the low pressure first and then the higher. The effect is to increase the capacity of the machine. Tests show that the capacity for ice making can be increased about 20 per cent with a reduction of 3 per cent in the power required per ton.

C. W. Koehler, who was later elected president of the Association, presented a paper on Absorption Refrigerating Machines. He pointed out the principles of operation and made some indications as to where savings might be made in the operation of this system. He brought out the point that for light cooling it was more economical to use a low temperature and circulate less ammonia than to use a higher temperature and with more ammonia.

Gilbert Sellers reviewed his own early experiences in the Manufacture of Raw Water Ice with apparatus of his own design. He told of several schemes he had for pumping cores which had proved successful and had been used until the advent of the air agitation process.

Electrical Drive for Ice Making and Refrigerating Machines was the subject of the address by William J. Bray, in which he covered more or less thoroughly the electrical end of the industry, giving special notice to the relative fields of induction and synchronous motors.

The subject of Treatment of Water for Raw Water Ice was dealt with from a fundamental point of view by W. J. Hughes. He reviewed the chemical changes which take place when the impurities that are commonly found in waters are precipitated or otherwise taken care of and showed on the screen methods of mixing reagents.

F. C. Pedley gave some practical hints on how to effect better Economies in the Ice Making and Refrigerating Plant. He spoke of the use of instruments and made it plain that in order for them to be of value their indications must be studied carefully and acted upon. He disclaimed the purchase of expensive indicating instruments merely for the adoration of the fireman. If you use instruments, educate your men in the interpretation of their indications.

Charles M. Gilbert followed with an enumeration of what should be done in "Overhauling and Rehabilitating Ice Plants." He emphasized the advisability of carefully inspecting the whole plant during the slack season and making any repair that might be needed rather than take a chance and wait for a defect to show up at a time during the rush season when its repair would cost ten times as much. At the afternoon session J. E. Porter read a paper on the Standardization of Ammonia Valves and Fittings. He enumerated the various differences that exist between the valves and fittings of the principal manufacturers of these articles and made a plea for a standard that all fittings might be interchangeable. He suggested that the N. A. P. R. E. unite with the American Society of Refrigerating Engineers and the manufacturers to establish a standard. In this connection the secretary of the A. S. R. E. read a letter showing the efforts that had already been made along this line.

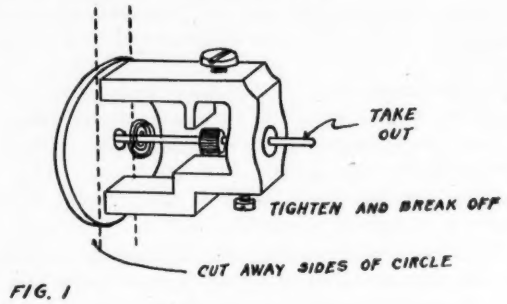
On the subject of standards, Mr. Voorhees mentioned the work by the A. S. M. E. and the A. S. R. E. in establishing a standard ton of refrigeration as 200 B.t.u. per minute. A standard suction pressure corresponding to a saturation temperature of 5 deg. F. and discharge pressure corresponding to a saturation temperature of 86 deg. F. was suggested. This would apply to all refrigerating agents.

H. C. Johnson of the department of inspection of Steam Boilers, Steam and Cooling Plants, City of Chicago, spoke on Municipal Regulation of Refrigerating Machinery Installation and Operation. He mentioned some of the rules which must be lived up to, and also the penalties for not doing so. He also had something to say on the service which the department renders in making plants safe.

U. S. Civil Service Commission announces an examination (receipt of applications to close Feb. 8) for technical instructor (chief machinist), to fill vacancies in the Ordnance Department at Large throughout the United States at $2000 to $2200 a year, and in positions requiring similar qualifications, at these or higher or lower rates of pay. Competitors will be rated on the following subjects: Physical ability, education, training and experience. Applicants must have a common school or equivalent education and completed a regular machinist apprenticeship, and must have at least 2 yr. subsequent experience as machinist, and have had 6 mo. experience as instructor in a machine shop. They must have reached their twenty-first but not their sixty-fifth birthday on the date of the examination. In view of the retirement act, at the request of an appointing officer, certification will not be made of eligibles who have reached their fiftieth birthday. Classified employes who have reached the retirement age and have served fifteen years are entitled to retirement with an annuity. Apply for Form 1312, stating the title of the examination desired.

Steam Gage Hand Puller

THE HAND PULLER of the testing apparatus became lost and to get some gage hands off, it was necessary to have a jig made just about for that purpose alone. Though the part itself is not a difficult piece to make when sufficient and proper tools are available, the few small tools consisting of a number of taps and drills which we had were certainly not much of a machine equipment. The jig was wanted at once and something had to be made as soon as possible.



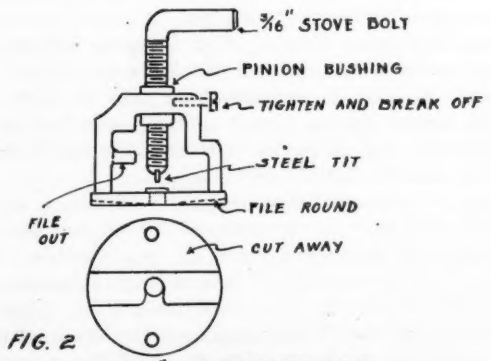


FIG. 1. PART OF OLD GAGE
FIG. 2. DEVICE FOR PULLING GAGE HAND

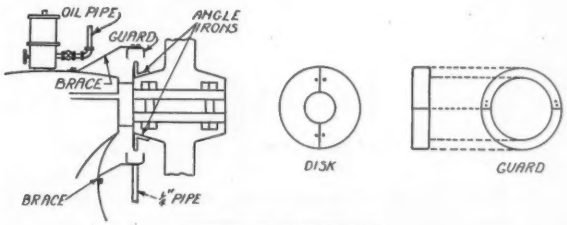
How one was constructed out of the movement frame of an old scrapped double-lane gage is shown by the sketches. The circular bottom of the frame was filed away until it was nearly even with the sides of the uprights, leaving only sufficient stock to strengthen the U-shaped hole, allowing the jig to slip under the hand to be taken from the shaft. The pinion bushing was drilled out and tapped to 3/16 in. for a stove bolt used as a jack screw. Into the end of the stove bolt, a 1/16-in. hole was drilled to take a bit of steel wire which pressed against the end of the hand shaft when the screw was tightened down. The interior of the frame was filed out a little for the sake of appearance, but utility was what was wanted. Almost any type of double-lane gage has this type of movement frame, and a scrapped gage readily affords the biggest part of the material out of which a practical makeshift puller can be made.

FRANK W. BENTLEY.

Keeping Oil from Belt; Globe Valve Causes Trouble

HAVING a direct connected high-speed engine and direct current generator, we wished to belt from the flywheel to an alternator. Everything worked well, but the bearing on the flywheel end spilled oil badly and thus got on the belt. As there was only about ¼ in. between hub of flywheel and end of bearing, it appeared to be quite some problem as to how the oil elimination process would turn out.

One engineer said: "Slow the oil on that bearing. It is getting too much, anyway."



DEVICE TO CATCH OIL

Another said: "If the oil is slowed on that bearing, I won't take any responsibility on my shift."

The engine was not designed to operate belt drive and the pull on the bearing allowed the oil to work out.

The problem was to catch the oil, as we positively could not stop it working out. Our final method of catching it was as follows:

A heavy 1/16-in. galvanized disk would just comfortably go between hub and bearing without danger of rubbing on the bearing. This disk was split as shown in the sketch and two angle irons were made to hold it to the hub of the flywheel. The angle irons are wide enough to bolt both halves of disk to a guard with sides overlapping an inch completes the trick. Centrifugal force throws the oil from the disk to the guard and the ¼-in. pipe carries it away. No more oily belt! Everybody happy once more!

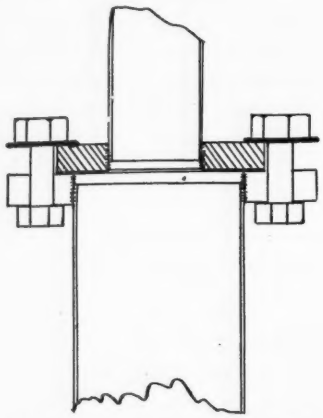
On page 1092, Nov. 15 issue, I note C. J. Miller's "Globe Valve Causes Trouble." The Massachusetts Boiler Rules say: "Where one or more globe valves are used on a feed pipe, the inlet shall be under the disc of the valve."

Mr. Miller's experience seems to prove that the Massachusetts law is good. Also, it would appear that

a water relief valve would have paid a pretty good dividend in this plant. Where automatic feed controls are in evidence, a pressure regulating valve on the pump is really not a luxury. TOM THUMB.

Emergency Piping Scheme

LAST FALL we were being rushed to get into service a new branch of our heating system and were working during Saturday afternoon and Sunday in order to get the system in service for the opening of the factory addition on Monday morning. Late Sunday afternoon when we were about completing the exhaust steam piping and were to join the 6-in. supply main to the new coils of the 10-in. main exhaust line, we discovered that a mistake had been made in ordering a standard 6-in. companion flange instead of a 6 by 16-in. which was needed to meet the flange on the 10-in. pipe.



EMERGENCY FLANGE JOINT ON HEATING SYSTEM

No 10-in. flange was available, so we met the emergency temporarily in the manner illustrated; that is, we took the standard 6-in. flange and turned off the outside edge so that it would fit inside the bolts of the 10-in. flange and bolted it up with washers as illustrated. It was so arranged that the next week when the 6-in. reducing flange was secured it could be quickly put in place because the 6-in. pipe was in the normal position it should finally occupy. M. A. SALLER.

"It Pays to Advertise"

THERE'S a broad difference between being egotistical and being justly proud. A man may accomplish something, and let it be known that he has accomplished something, without becoming egotistical.

Recently, a young engineer friend of mine came to me and complained that while he had made great headway in reducing the expense in the plant where he worked, yet the bosses did not seem to be noticing it, and instead of showing some appreciation of what he was doing, they seemed to be expecting more of him every day. He was thinking of resigning, but several friends had advised him to hold on; that if he kept doing his full duty, and watched his affairs, cutting out all the expense that he could, he would finally come under the notice of the owners, and they would recognize his ability.

Now I have been offered the same advice a lot of times, and heard it offered to others a lot more times and admit that it is good a greater part of the time, just as far as it goes. But we will suppose that a good honest man goes into business, stocks up with the very best goods obtainable, hires the most efficient help, gives a service unequaled by any other store of its kind in the community; how much time would be lost in building up a good business if he stopped right there and waited for people to discover the facts? But a good business man does not stop right there; as soon as he knows that he is equipped with the things that are worth something to somebody else, and is ready to deliver the goods in a way that the other fellow wants it, he proceeds to tell people about it, in a way that they understand, using language that will appeal to them, with figures that talk in dollars and cents that they cannot deny, and the result is, that instead of sitting still and waiting for something to come to him, he gets out and gets it in about half the time.

I once knew an engineer who took the foregoing advice and kept making money for his firm, and finally they recognized the fact that he was responsible for a great part of their prosperity, and started paying him accordingly; but about that time one of the members of the firm died, and to wind up his estate, the business was sold out, and the new owners brought their own crew. The result was that the engineer had to look for a new position. He had absolutely lost what was his by right for years, by not advertising his wares.

All of you readers have read advertisements that did not ring true, and you could not have explained to save your life what was wrong about them. Yet if you have been a close observer of things, you remember that after a while the advertisements stopped and when you made inquiry, you found that the firm doing the advertising had ceased to exist. In other words, before advertising can pay, it must be for something that is worth the money, backed up by honest service, described in an honest way. And all the advertising in the world cannot keep an inferior article on the market.

Now, an engineer has something to sell and is selling it every day that he is employed. The question that came up with me several years ago was whether I had a right to advertise what I was selling the same as a merchant. I decided that I certainly did. Then, as with the merchant, I cast about for the best and most convincing way to do it. The pages of the magazines and newspapers were not open to me, for the general public was not interested in my ability. It would be egotistical as well as a waste of money for me to use printers' ink. There were only the men who employed men of my trade that could possibly intend to buy my wares—ability and service.

At the time these questions were bothering me, I was employed in a plant similarly to the young engineer referred to in the beginning. Our concern was making more money than usual. Each month's balance sheet was showing a little gain. The superintendent was strutting around like a peacock all the time, leaving the impression on every one that he was responsible for it all. I am not denying that he was a very efficient man; but one day in the course of a conversation, the thought struck me that he was "advertising" and I saw where

my trouble was. I had been working my head off reducing expenses here and there, and with all the books kept he had the advantage of making the whole deal look favorable to him and his management. This started me thinking. Why not keep a set of records that would show what I was doing from month to month?

Without consulting anybody, I figured out my plan. I would not purchase a single item for the engine room of which I did not first know the exact price. I talked with the people who supplied our fuel, and arranged with them to furnish me with a statement of the tonnage and price every month. Upon my request, one of the fuel people furnished me with the monthly purchases and prevailing prices of fuel for every month that I had been in charge of the engine room, as well as the 12 mo. previous. I sat down with these figures before me and made up a monthly comparative statement covering 4 yr.

I then made up a list of every important change that had been made under my management. I showed in plain figures in what each of these changes had resulted. Then I started in to keep a log of each day showing the average load that was being handled in each department that required power. Some of it had to be estimated, as I did not have the instruments to record it all; but I would figure some plan whereby I could arrive at a safe conclusion that would stand up under close examination. When I got everything in shape, I got out a nicely typewritten statement of "FACTS" and sent a copy to the superintendent one day, and another copy to the owners the next day. I did not want to do anything that the superintendent would think was undermining, but those facts had even opened my eyes to what I had accomplished there and I proposed to ADVERTISE myself.

The result was a handsome increase in salary. Not $5 or $10 a month, but $5 monthly raise accompanied with a check, marked "In Appreciation of Good Service," for $150. The superintendent, himself, brought me the check from the owners and instead of being sore over the matter as I thought he would, he told me that from then on, the engine room accounts would be kept entirely separated from the other department expense accounts and would be open for my inspection at all times and that he would appreciate a monthly comparative statement against previous months, made out as I had made the general statement. He said that if he could have it every month for his files, it would lessen his work a lot.

Since then, he is using the same plan in other departments and says it saves him money. I have had another nice increase as a result of it.

If advertising will pay one man in a certain line of business, it will pay another man in his line of work, if he goes about his advertising in an intelligent way. I have found out, however, that you will have to spend as much time on making the article you are going to advertise, worth the money. Then make your advertisement ring true, so true that it cannot be disproven. Next select the method of advertising that suits your particular needs the best, then follow up the plan until you get results. If you are a good engineer, you will be a better one after you have convinced yourself of the fact. If you are not a good one, you can't expect to convince the other fellow for you *can't convince yourself*.

Remember, though, that whether it be a pair of shoes, a barrel of flour, or services, the advertising must be for a superior article, and must be along legitimate lines; and advertise your own product and let the other fellow's alone. H. A. CRANFORD.

Home Made Automatic Pump Stop

ABOUT 2 yr. ago, a home-made automatic pump stop was made by an operating engineer. It worked fairly well, but the pump had to be started by the attendant every time it stopped. The enclosed sketch shows the same stop with some improvements added. The tank is closed; the cylinder, C, can be made from a piece of turned-out extra heavy iron pipe, with a stuffing-box arranged on the top end. The piston is a pair of iron washers and a cup leather, with the lips turned up.

The pressure required on the tank was 10 lb.; however, a greater pressure could be secured by resetting the relief valve, B, and increasing the weight, W. Closing valve A will automatically close the steam valve, thus shutting down the steam pump.

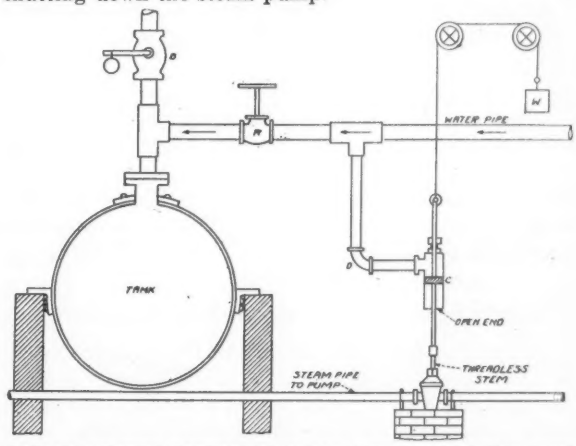


DIAGRAM OF PIPE CONNECTIONS FOR AUTOMATIC PUMP STOP

It is obvious that the cylinder, C, will have to be drilled and tapped to take in the branch, D. The smaller the size of D, and the larger the diameter of C, the slower will be the operation of the stop. The bottom of the cylinder is open. JAMES E. NOBLE.

Purging Ammonia Condensers

IN THE issue of Dec. 1, R. J. Solomon suggests as an improvement the transfer of the purge valve from the top of the condenser coil to the bottom; his opinion in the matter being based on the difference of density between ammonia gas and air.

Air is not the only undesirable gas found in condensers; in fact, in a well operated plant, very little air gets in the system. Leaky stuffing-boxes and pumping down to a vacuum may introduce air in the system, but the experienced refrigerating engineer seldom pumps down to a vacuum except in case of absolute necessity. The gases that are troublesome in the condenser are formed by the decomposition of ammonia into non-condensible permanent gases (mostly hydrogen and nitrogen), that cannot be condensed back to liquid anhydrous ammonia, and therefore are objectionable in the system, as they occupy space in the condenser coils and reduce

the cooling surface in proportion to their volume. Their presence is evidenced by an increasing condenser pressure and abnormal heating of the compressors and piping from compressor to condenser. The density of the hydrogen and nitrogen gases thus found is much lighter at equal pressure than that of liquid anhydrous ammonia, therefore they accumulate in the highest part of a condenser coil at rest.

The specific gravity of nitrogen (0.971) is greater than that of ammonia gas (0.626), but ammonia gas can be reduced to liquid ammonia by the circulating water at 60 deg. F. with condenser pressure of 125 to 150 lb., while the nitrogen will remain a gas, lighter than liquid ammonia.

If we follow the procedure indicated by Mr. Solomon, closing the inlet and outlet ammonia valves on the condenser coil and allowing the water to circulate through the condenser, eventually the condensible ammonia gas will be changed into liquid anhydrous ammonia that will fill up the bottom part of the coil, and when we open the purge valve that he places at the bottom, we will first draw all the liquid ammonia there is in that coil.

Evidently this procedure would cause a greater waste of ammonia than that which Mr. Solomon is trying to remedy.

I would advise him to stick to the old method of purging from the top of the coil, purging into a receptacle containing water, and closing the purge valve as soon as the gas bubbles stop coming up through the water and a hissing sound similar to that produced by the admission of steam into water announces the presence of ammonia gas. H. ROBIN.

Train Engineers as Foreign Representatives

THE EXCELLENT editorial, in the Dec. 1 issue under the head Opportunities for American Engineers, is most timely. I am both a reader and a subscriber to several publications, devoted to mechanical industries, but Power Plant Engineering was the first to call attention to this most important subject. One reads from time to time about the foreign, or export business and the advisability of sending engineers and representatives. But do our manufacturers do this thing? They do not! When approached upon the idea, with few exceptions, they content themselves with, "Oh, we send machinery, etc., and furnish blueprints and directions for installation," and let it go at that. And when a complaint is received that the machine at plant does not do the work, they attribute it to not following directions. Now, in some cases, the blueprint, etc., works out O. K.; but in many instances it does not, and the result is that the machine gets a "black eye" and the foreign purchasers exclaim: "Oh, it's only another of those 'Yankee' contraptions, made to sell, etc."

Having traveled considerably, both in South America and the Orient, I speak from personal observation and contact. Why is it that one meets engineers from England, from France, from Italy, Belgium, and, I might add, from all European countries, and seldom one from "Yankee Land"?

If our manufacturers desire to do business in foreign lands, why do they not send trained men both to install and to demonstrate their goods? True, it means an expenditure of both money and time, but if other countries can afford to do so, and it's worth while, why not go to it? Nothing is gained by this continued talk and writing if we fail to act, and now is the time. Let us start training our men at once, as is the case with European firms, give them a preliminary insight, also some linguistic practice, and send them to the fore. The establishment of branch houses, with trained representatives, is an absolute necessity, if we are to expand with the trade of the world at large; trade by correspondence is indirect, and the personal equation, or appeal, plus demonstration by men who know the game, is what we need. O. JASON MILLER.

What is a 45-Deg. Elbow?

A PIPE fitter points out the fact that the name "Forty-five-degree elbow" is a misnomer. A 45-deg. elbow looks like Fig. 1.

The angle A O B is a 135-deg. angle. Therefore, why not call it a 135-deg. elbow?

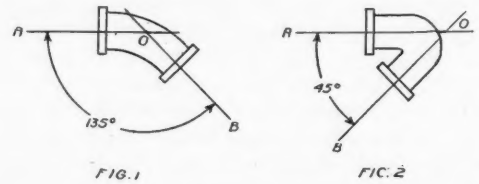


FIG. 1. SO-CALLED 45-DEG. ELBOW
FIG. 2. WHY ISN'T THIS CALLED A 45-DEG. ELBOW?

Of course, the experienced pipe fitter knows what a 45-deg. elbow is, what it looks like, and probably he knows why it is called a 45-deg. elbow; however, to the uninitiated, and for the sake of greater exactness, it would be more accurate, perhaps, to call Fig. 2 a 45-deg. elbow. It looks more like one, anyway. N. G. NEAR.

Efficient Services are Appreciated

IN THE Nov. 15 issue is an article by H. A. Cranford which greatly interests me, for its bearing on my own experience in the past three years.

I am chief engineer of a small western plant with 55 tons of refrigeration and two 35-hp. units for power and lights and two 72-in. by 18-ft. return tubular boilers, 13-ton ice making plant, 16 tons on sharp coolers in the ice cream department, and the remaining six tons take care of the storage easily.

This plant has been in operation since June 4, 1911, and was operated until March 4, 1917, without being overhauled, so the reader can imagine the shape the machinery was in. The man who was in charge was a fine fellow, but was raised on the one job, so was afraid to overhaul a machine not understanding the work, also afraid to ask for anything new because he could not explain why he needed it.

I came to this place from a large brewery which was quite modern and kept in good shape, so my employer expected me to make great improvements, but when my repair expense began to rise, he started asking questions and hedging.

I was able to answer his questions satisfactorily and also showed him that the plant was unable to run much

longer without repairs. By the end of the year the plant had done a third more business than the preceding year. Steam coal had advanced $1.25 per ton over the preceding year, but cost only $1000 more than the year before.

The last two years the plant has done more each year and from my coal records the coal consumption per ton has not increased. I have met the increase in oil prices by installing oiling systems, which also helps on the pay roll expenses.

I keep records of my plant such as the steam, coal burned, water used, current used, oil and other supplies. I don't have time to run any test, but I think my record will show me when anything is wrong.

Most gratifying of all, personally, my wages since coming here have doubled, also now I have complete charge of the whole plant, do my own buying of all supplies, also replacements of machinery, and make new additions when I think it is time. J. E. Bates.

What Do You Know About Oil?

When the situation narrows down to a question of what you know about oil, where do you stand?

Are you availing yourself of the opportunities thrown in your path these days, to better your knowledge of the oil which you use every day?

When you reflect that the entire industry of the world is dependent on the judicious use of oil, should you not know the fundamental principles of its use and abuse?

Your employer places confidence in you by placing you in charge of his plant. He expects results, more than that, he expects you to take care of his equipment. His plant is his livelihood; moreover, it is yours. Are you taking care of it or are you destroying it?

Take, for a concrete example, the case of two everyday chief engineers. One knows absolutely nothing regarding the use or properties of the oil he is using and the other, having given some little time to its study, is capable of talking intelligently on the subject.

The first man suddenly experiences trouble with his oil. He knows that his cylinders are beginning to score and his engines groan at every stroke; but being unable to put his oil to any test whatever, he registers a kick with the firm from which he buys his supplies.

They send a lubrication engineer to his rescue. This man looks into conditions, tests the oil and finally reports that the oil is not suitable for the plant's needs.

The engineer asks the oil man what the trouble is with the oil. He replies that there is absolutely nothing the matter with the oil. It is the conditions with which the oil has to contend that are responsible for the oil's failure. He tells the engineer that this oil was never compounded for such use. The engineer takes this personally and feels rather hurt that the oil man thinks his plant is not in shape. That is not the point; the plant may be in perfect shape, but such oil would never operate it for a day without some deterioration.

The lubrication expert finds out that his firm has made an error in sending this certain oil to this plant and soon rectifies matters.

Meanwhile, this oil has been playing hob with things and might possibly mean a rebored cylinder or valves. Who can tell what havoc the mistake has wrought in the aggregate? Waiting for the lubrication engineer has cost your firm money. That is a fact no matter at what angle you view it.

When his trouble starts, the second man immediately makes a test of the oil *himself*. Possibly, he learns that the flash point of his oil is several degrees below what his contract with the oil company calls for. No wonder he is having trouble. With the pressure he carries, this oil is bound to fall down. He at once gets in touch with the oil company and in straightforward terms tells them what is wrong with the oil. The oil company realize that this man knows what he is talking about. In fact he is as well versed in their business as they are themselves and they are quick to respect his knowledge and remedy his trouble. Thus he gets what he wants and gets it in a hurry. He saves his employer money and gains the respect of his fellowmen.

Moral: Let each engineer be his own lubrication expert. J. W. Shaw.

Serious Shaft Accident

While I do not know how many ideas have been suggested, or how many safety devices are on the market, I do know that something is needed to protect a man while working about revolving shafts and pulleys.

Jess Gondora, 35 yr. old, suffered a fractured right arm and a crushed chest when his sleeve was caught by a swiftly revolving pulley in the Grossman Progress Laundry at Denver. Gondora was standing on a ladder repairing a pulley belt at the time. He was whirled against the ceiling with great force before follow workmen could stop the machinery and rescue him. He was removed to the county hospital. Physicians say he will recover.

I cannot think of anything better than a thin rubber sleeve that will fit the entire arm snugly, giving free use thereof, and at the same time prevent any part of the shirtsleeve from being exposed to the revolving units. These protective sleeves should be well taken care of and nobody allowed to work around machinery in motion unless properly garbed.

Even to think of working about such machinery with vest wide open, watch chain dangling, shirtsleeves flaping—perish the thought!

J. B. Dillon

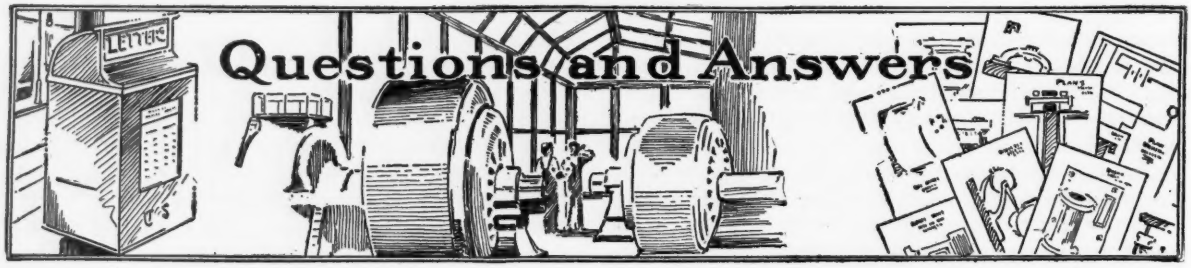
Steel Belt Causes Fatal Accident

A steel belt at the Burlington Railway shops at Denver, Colo., driven by a gasoline engine, slipped from a pulley and struck O. R. Ellis, 38, foreman for the Ogle Construction Co. of Chicago, on the head, fracturing his skull, death resulting. At the time of the accident, he was standing about 4 ft. from the engine.

Mr. Ellis had been in Denver about 3 mo. supervising the erection of steel sheds for the Burlington Railway.

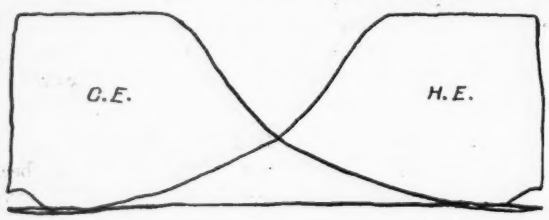
J. B. Dillon.

The Granite Falls Mfg. Co., Lenoir, N. C., manufacturer of cotton goods, plans to erect a new hydroelectric power plant in the vicinity of Lenoir for works, service and general light and power service in that district.



Why the Excessive Back Pressure?

THE ACCOMPANYING indicator cards were taken from a 12 by 24 by 30-in. engine running at 108 r.p.m. The boiler pressure is 85 lb. per sq. in. gage. What is the cause for the rapid falling off of the expansion line, why



DEFECTIVE CARDS FROM A 12 BY 24 BY 30-IN. ENGINE

is the back pressure so high and what causes the hook on the compression line? I would appreciate the opinions of the readers of Power Plant Engineering as to what causes these defects and how they may be remedied.

H. M. R.

Feeding Water Through the Blowoff

WHAT IS your opinion as to the advantages and disadvantages of feeding a boiler through the blowoff pipe instead of through the front shell? T. C. P.

A. In regard to your question about feeding through the blowoff pipe of the boiler; it is true that this gives circulation in the blowoff pipe and tends to keep the blowoff clear. As you are taking water through a feed heater, there will be no serious strain on the plates from feeding in this way; but our own opinion is against this method of feeding.

To get the best results from blowing down, it is desirable that the solid matter thrown down from the water shall collect on the bottom sheet at the back end of the boiler near to the blowoff so that it will be swept out of the blowoff with the outgoing current of water. If the feed is through the blowoff, the tendency is to drive the sediment away from this point so that there is less chance of getting it down when the boiler is blown down. Sediment is not likely to come down from the water immediately when it enters the boiler. The water, even if a good heater is used, will not be up to the temperature inside the boiler and, until it is heated up and also has a chance to slow down a little, the sediment will not be thrown out of it.

In case of feeding through the blowoff, there is a tendency for the water to pass forward through the front end of the boiler before it becomes heated enough to rise toward the steam space. This will mean that the sediment will tend to drop out at the front end of the boiler over the hottest part of the fire, the worst possible place to have it, as the intense heat will bake it to the plates and set up a heat insulation at the very point where the most rapid transmission of heat is wanted.

The better way is to enter the feed pipe at the front of the boiler below the steam space and carry it back the full length of the boiler and then turn it downward with a tee, having the straight run of the tee plugged. There should, of course, be a union connection close to where the feed pipe enters the front head and on the outside so that, by disconnecting this and taking out the plug in the tee at the back, this feed line can be rodded through and cleared. This gives the feed water a chance to heat before it leaves the inlet pipe, but it is still flowing rapidly enough so that the solid matter will not be thrown down to any extent. This water will then settle toward the bottom of the boiler near the blowoff and will have a chance to give up the solid matter at the blowoff where it can be readily disposed of.

Valve Setting

I HAVE a Corliss cross compound engine built by the Laidlaw-Dunn-Gordon Co. It is condensing and of the double eccentric type, cranks set at right angles to each other, steam eccentric set 90 deg. ahead of the crank on high pressure side. Where would the low pressure steam eccentric be? By how many degrees would it lead the crank? Would it be the same as high pressure side?

2. By how many degrees does the exhaust eccentric lead the crank on both sides?

3. If I make the cutoff early on the low pressure cylinder, how would this affect the cutoff on the high pressure cylinder?

4. What would be the proper receiver pressure to carry on this engine 12½ and 25 by 24 by 8 in., 100 lb. gage pressure, high pressure cutoff ⅓, low pressure ¼, when the load is constant?

5. How is the valve of a Harrisburg high-speed engine set? How high will 28 in. of vacuum lift water? Is it figured the same as 30 in.? C. H. M.

ANSWERS

IN YOUR ENGINE there would seem to be no reason why the two steam eccentrics should not be set at the same angle ahead of the crank for both high and low pressure cylinders, but this will depend on the design of the engine and cannot be told without knowing all the dimensions. Ordinarily the steam eccentric is set as equally as possible with the crank so as to secure the

longest possible range of cutoff, and the exhaust eccentric is set ahead of the crank by 90 deg. plus the amount to bring release slightly before the end of the stroke.

2. Setting the steam eccentric further ahead of the crank will reduce the range of possible cutoff, while setting the exhaust eccentric ahead will bring release earlier and compression earlier. Judgment is made until a satisfactory indicator diagram is secured.

3. Setting the cutoff early on the low-pressure cylinders would change the receiver pressure, but would not affect the high-pressure cutoff, as that is controlled by the governor according to the load.

4. We are somewhat puzzled by the figures that you give in regard to your engine, but assume that you have steam cylinder 12⅛ and 25 in. in diameter by 24-in. stroke with an 8-in. compressor cylinder. On this basis, with high-pressure cutoff at ½ stroke and 100 lb. initial pressure, you should be getting about 20 lb. pressure, assuming that there is 28 in. vacuum in the condenser.

5. Setting of the valve on a high-speed Harrisburg engine is exactly the same as for a plain slide valve. The governor should be blocked out to running position; the engine is then set on one dead center and the eccentric turned forward to give the correct amount of lead. The engine is turned to the other dead center and the amount of lead checked up. The valve stem should be lengthened or shortened until these two leads are practically the same. On an engine of this kind there is not much judgment to be made, as this is all fixed by the design of the governor and valve motion. Figuring the height of water lifted by a 28-in. vacuum is practically the same method as for a 30-in., and would be 31 7/10 ft.

Fundamentals of Electricity

WILL YOU kindly answer the following questions for me?

1. What governs the rate of current flow of a primary cell?

2. What governs the division of current in the different paths of a parallel circuit?

3. Is there any division of current in the different parts of a series circuit?

4. What formula is used when calculating the combined resistance of only two unequal circuits if connected in multiple?

5. What would be the combined resistance of two lamps, when connected in multiple if one had a resistance of 10 ohms, and the other 5 ohms?

6. If 6 amp. were maintained in the circuit in question, No. 5, how much current would each lamp get?

7. What is the combined resistance of six coils connected in multiple if their separate resistances are respectively, 1, 2, 3, 4, 5 and 6 ohms? J. M.

ANSWERS

THE RATE of flow of current from a primary cell is proportional to the voltage drop in the exterior circuit and inversely proportional to resistance.

2. When a current flows through a parallel circuit, the sum of these currents is equal to the main current. These component currents are proportional to the voltage drop and inversely to the resistance of each path.

3. There is no division of current in the different parts of a series circuit.

4. The combined resistance of two parallel circuits is equal to the reciprocal of the sum of the conductances of each division, that is:

$$\frac{1}{r} = \frac{1}{r_1} + \frac{1}{r_2}$$

where r is the resistance of the entire system, r_1 is equal to the resistance of one path and r_2 of the other.

5. The combined resistance of two lamps connected in multiple, one having a resistance of 10 ohms and the other 5 ohms, can be found from the equation above.

$$\frac{1}{r} = \frac{1}{10} + \frac{1}{5} \text{ from which } r = 3.33 \text{ ohms.}$$

6. If 6 amp. are maintained in this circuit, the current consumed by each lamp can be found from the equations:

$$I = \frac{E_1}{r_1} \times \frac{E_2}{r_2} = I_1 \times I_2$$

and $E_1 = E_2 = E$

from which, $I_1 = 2$ amp., and $I_2 = 4$ amp.

7. The combined resistance of 6 coils connected in multiple with resistance of 1, 2, 3, 4, 5 and 6 ohms, can be obtained from the equation:

$$\frac{1}{R} = \frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{5} + \frac{1}{6}$$

from which, $R = \frac{60}{147}$ or 0.408 ohms.

Alternator Hunting

WE HAVE here two 800-kw. generators, three-phase, 480-v., direct-connected to two 24 by 48 by 42-in. cross-compound Corliss engines running condensing. Our load increased until it became necessary to run them both at the same time. We phased them out, but when we run them together the ammeter begins to fluctuate and gradually increase until one or the other circuits kicks out. What is the cause of this situation?

J. M. H.

A. Evidently your two generators, when connected in parallel, are playing the game called hunting, due to the change of speed. In paralleling a. c. generators, the load cannot be divided between the machines by changing the voltage as is done in the case of direct current generators operated in parallel.

Hunting is caused by the variation in the speed of the engine. When one engine tends to slow down a trifle, its alternator will act as a motor to pull it back up to speed. Of course, the governor on that engine will also act, with the result that the lazy engine will try to speed up faster than the other and in turn it will become driver, trying to pull the second engine up to its speed.

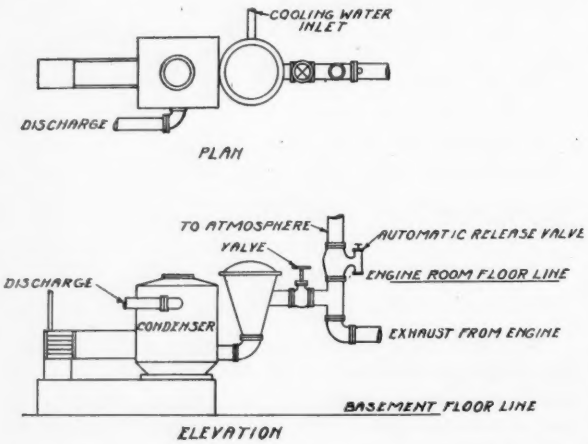
The difficulty is that the governors on your engines are too sensitive. If you will apply a dashpot to the governor or if there is already one used, try putting in a little heavier liquid so as to slow down the governor action. I think you will find it will help the condition. It is essential, however, that the governors should be set so that they will tend to hold the two

generators at exactly the same speed and this may mean some regulation of your governors; but probably by changing the counterpoise, which I presume is used, you can accomplish this result.

I RECEIVED your instructions today and am glad to inform you that your advice is correct and that we have the two alternators running together steady as a clock. This is what I did. I took the oil out of both dashpots and poured them together and after thoroughly mixing them I put them back in and from then on I had no trouble. J. M. H.

Exhaust Steam Heating

I ENCLOSE A SKETCH showing the connection to our jet condenser from our engine, a cross compound 4-ft. stroke, high-pressure cylinder 20 in. diameter, low pressure 48 in. diameter. We maintain a 25-in. vacuum and operate on about 85 lb. at the throttle.



CONDENSER CONNECTIONS TO AN ENGINE

The mill is heated with live steam direct from the boilers to long rows of pipe coils overhead in the different departments. All these coils are hooked into trays and water is allowed to flow to the sewer. Can you tell me of a system whereby we can use our exhaust steam for heating purposes? Is there a firm that specializes on this, or can you refer me to some book that will give me the data?

You will note on the sketch that there is an automatic release so that the engine can exhaust to the atmosphere in case the condenser stops or somebody happens to close the valve. This, it would seem, would aid in using the exhaust steam for heating, as any choking of the system would not harm the engine more than to raise the back pressure. V. K. N.

A. You are now running a compound engine with 85 lb. initial pressure, which would give theoretical heat efficiency of 24.6 per cent. If you should use the exhaust steam for heating, putting a pressure of presumably 5 lb. on the exhaust, it would reduce the theoretical heat efficiency to 12.6 per cent.

It is probable that under these conditions a simple engine would be quite as efficient as a compound, especially if your load varies appreciably.

Unquestionably, you can connect the exhaust steam for heating, by the method you outline. It is simply a question of whether, for the amount of steam that you need for heating, it would be more economical to use live steam or exhaust.

It is, of course, possible to take steam for heating, in case you do not need all that the engine exhaust gives, from the receiver between the two cylinders; but there is no way of telling whether this would be advisable or not without knowing the amounts of steam that are necessary to do your heating.

What's a Watt?

WILL YOU kindly define and explain the following? What is a watt of electrical energy? What is a kilowatt? What is a 150-kw. generator?

2. How do you get the output of a generator by reading a three-phase watt-hour meter?

What will be the result on generator if one of the phases is overloaded?

If the overloaded phase winding breaks down, will it affect the other two phases?

3. If a motor is operating on an unbalanced three-phase system, will the power output be affected?

T. C. P.

ANSWERS

YOU HAVE some misunderstanding of what is meant by the watt and the kilowatt. This is not a measure of energy, but a measure of power, comparable to the horsepower in mechanical units. It is the rate at which work is performed. You probably know that the horsepower is 33,000 ft.-lb. per minute; in like manner, the watt is the work done by the application of a force of one erg for one second, the erg being the energy unit for the electrical system the same as the foot-pound is for the mechanical system.

To get an idea of what the watt is like in size, 746 w. is equal to one horsepower. One watt is equal to one ampere of current flowing under an electrical difference of potential of one volt, that is, the number of volts on a system or a circuit times the number of amperes flowing gives us the watts. The matter of time does not enter in. We measure electrical energy by watt-hours, which is the equivalent of horsepower-hours, the watt-hour being the energy supplied when a current delivers one watt for one hour. The kilowatt is 1000 w. and is used simply to get a smaller number of figures when dealing with the output of large machines. A 150-kw. generator is capable of supplying electrical energy at the rate of 150 kw. or 150,000 w. and in one hour can deliver 150,000 w.-hr.

2. As to the wattmeter questions, a three-phase watt-hour meter properly connected, will record the number of watt-hours passing through a three-phase system. To get the output in watts, it is necessary to take the difference between the readings of the instrument an hour apart; this will give the watt-hours supplied during that time and will also be the watts rate of supply. A 150-kw. generator should show on the chart 150,000 w. hr. delivered over a period of an hour. There is nothing in the record of a three-phase meter which will show whether one phase is overloaded or not. The effect of

overloading one phase, unless the overload is carried beyond the capacity of the winding of the generator, is not serious, but one phase may be overloaded by extra lighting load or a single phase motor to a serious point, and in that case, the windings for that phase on the generator will be overheated and the insulation burned the same as if the whole machine were overloaded. With a properly installed system, however, the fuse or circuit-breaker on that phase would open up long before any harm was done. To get the best results, the three phases should be in balance, that is, each phase carrying practically the same current, and this will be shown by the ammeter readings, as there should always be an ammeter on each wire and the readings on the three phases should be the same.

3. Unbalancing will not affect a three-phase motor unless the unbalancing is so severe as to cause a lower voltage on the overload phase. In that case, it will cut down the power which the motor can deliver, but it would be quite unusual for the unbalancing to be as serious as that.

Effect of Eccentrically Placed Rotor

I HAVE a 100-kw. direct-connected alternator running at 198 r.p.m., which is carrying full load of induction motors and lights of which about 85 per cent are motors and 15 per cent lights. I have considerable trouble in keeping the voltage up where it should be and have a power factor of about 80 per cent.

I notice that there is ⅛ in. more space between the field poles and armature on one side of the generator than on the other. By this I mean the field does not revolve in the center of the armature.

Please advise me whether, if I were to change this and make it run in the center, it would not make a difference in the voltage. Also, would it make any improvement in the power factor, and would it help relieve the load on the engine? J. S. Y.

A. The windings on that side of the armature to which the field is the nearest will, due to the lesser reluctance offered by the adjoining air gap, tend to have induced within them a higher voltage than the other parts. Just how this will affect that terminal voltage depends upon the arrangement and type of armature windings employed; but it is a safe guess to say that, if anything, the terminal voltage will not only be reduced, but circulating currents may be established which will cause heating and an excessive load on the engine. In any event, we would advise you to shift your revolving field so as to secure a uniform air gap.

We doubt if this misplaced field will materially affect your power factor; it will not, we know, bring it down to 80 per cent, as you state it now is. This must be due to the inductive nature of the load you are carrying, which presumably is made up, to a marked extent, of induction motors, many of which are, perhaps, of small capacity and underloaded.

You may improve your power factor by installing a synchronous motor and operating that with an over-excited field, so as to draw a leading line current, which will have a tendency to neutralize the lagging current. We would further suggest that you eliminate as many of your small motors as is possible and keep the motors you have operating at full load.

Pump Connections

WE HAVE under operation two centrifugal pumps connected up to a 30 in. suction with a "Y" and while one pump is running the other one will not lift the water. Why?

2. On a double eccentric Corliss engine, what relation have the eccentrics to one another and also to the crank? W. F. D.

ANSWERS

THE DIFFICULTY with your pumps is that one of them creates, when running, a stronger suction than the other and, of course, that one gets all the water. The connection which you have of two suctions to a single "Y" is not desirable and you should, if possible, separate these, running separate lines to the source of supply. If this cannot be done, you will have to cut in a valve in the section of the pump which is not taking all the water between the "Y" connection and the inlet to the pump. This valve can then be closed down until the suction from the two pumps, at the point of the "Y" connection, is equal, when they should divide the water between them.

2. On a double eccentric Corliss engine, the idea is to set the steam eccentric as nearly as possible parallel to the crank; that is, the angle of advance for the cutoff eccentric is as near zero as possible depending upon the design of valve motion. The exhaust eccentric is set ahead of the crank 90 deg. plus whatever angle is necessary to bring the release and compression at the proper points. This again, will depend on the design of the valve motion and the valves themselves.

Governor Trouble

IN ANSWER to a question which appeared in your Nov. 15 issue under the caption "Governor Trouble," I will say that I have experienced similar trouble with this type governor (Buckeye). The cause, I find, in most cases, is due to friction on the riding cutoff valve rod. This rod usually wears at the gland so that the packing has to be put in under considerable pressure which only aggravates the trouble and produces excessive friction. The packing I find best for this purpose is metallic asbestos which can be left fairly loose.

Another reason may be that the cutoff valve leaks so that there is too much pressure on it which would throw it out of balance. A valve has to be very nearly balanced in order that a governor of this type will handle it.

Again, the governor springs may be out of balance, or the pins might bind, or it may be possible that the eccentric strap binds enough to cause the trouble.

J. W. L.

Balled Up?

WEIGHT 30 tons; dimensions 6 by 8 ft. by 20 in. Twenty-five men required to unload and place this massive chrome steel door in position at a Denver bank. Regardless of all of that, only one man is required to manipulate the door after it was placed in position. Sounds like a fairy story, but it is the truth and the secret of the whole thing is—ball bearings.

J. B. DILLON.

POWER PLANT ENGINEERING

Trade-Mark, Reg. U. S. Pat. Office

Issued the 1st and 15th of each month. Established over 25 yr.

Published by the TECHNICAL PUBLISHING CO.
537 South Dearborn Street, Chicago.
New York Office, 150 Nassau St.

Subscription price $2.00 a year in postal zones 1, 2, 3, 4 and 5, which include all postoffices within a distance of 1400 miles from Chicago.

Subscription price $2.50 a year in postal zones 6, 7 and 8, which include all postoffices more than 1400 miles from Chicago.

Copies, current issue, 15 cents; back numbers, 25 cents.

Notify us at once of any change of address, giving the old and the new address, so that your paper may always reach you promptly.

Copyright, 1921, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers.
Member, Audit Bureau of Circulations.

Circulation of this issue 22,000

CONTENTS

Pumping Plant of New Hunter's Point Drydock. Illustrated..151

Long Distance High-Pressure Steam Line. Illustrated.....157

Application of Waste Heat Boilers to Open Hearth Furnaces. by Thomas R. Tate.....160

Value of Metering Fuel Oil and Water. By Allen F. Brewer..161

Boiler Feed Water Regulation. By Roland Moeller. Illustrated 162

Reducing Hazards in the Engine Room. Illustrated.....164

As a Man Thinketh. By H. A. Cranford.....167

Electrical Features of Motor Installations. By Gordon Fox. Illustrated 168

Protective Relays. By H. P. Sleeper. Illustrated.....173

Experiences at Glendale. By G. H. Kimball.....178

Tilting Trap Troubles. By H. A. Jahnke. Illustrated.....180

Refrigerating Engineers Meet.....183

Letters Direct from the Plant: Steam Gage Hand Puller. Keeping Oil from Belt; Globe Valve Causes Trouble. Emergency Piping Scheme. "It Pays to Advertise." Home-Made Automatic Pump Stop. Purging Ammonia Condensers. Train Engineers as Foreign Representatives. What Is a 45-Deg. Elbow? Efficient Services Are Appreciated. What Do You Know About Oil? Serious Shaft Accident. Illustrated.....185

Questions and Answers: Why the Excessive Back Pressure? Feeding Water Through the Blowoff. Valve Setting. Fundamentals of Electricity. Alternator Hunting. Exhaust Steam Heating. What's a Watt? Effect of Eccentrically Placed Rotor. Pump Connections. Governor Trouble. Illustrated.....190

Editorial: Attractive Design of Power Plants. Attention to Details 194

Off Duty 195

Weighing Feed Water. Illustrated.....196

A New Furnace Instrument. Illustrated.....197

A Combustion Guide for the Fireman. Illustrated.....198

Washington Letter. By A. P. Connor.....199

News Notes 199

Book Reviews 200

Attractive Design of Power Plants

It is a generally conceded fact that the most vital points to be considered in the design and operation of power plants are those relating to service and efficiency. The first requirement demanded of a machine is reliability under all normal operating conditions, and, secondly, economy of operation. A piece of apparatus may be highly efficient but unless it can at the same time render a good grade of service, we have little use for it. It is often advisable to sacrifice a bit of the available efficiency in order to gain uninterrupted service.

There are, however, other important points in addition to those of service and efficiency to be considered. Among these may be mentioned neatness and good appearance. Beauty in a power plant may have no direct commercial value, yet the esthetic effect of an attractively designed plant will unquestionably be reflected in the character of the work of the men in charge.

Polished brasswork and pleasing colors in an engine room may not increase the thermal or electrical efficiency of a turbo-generator one iota, but that it will ultimately increase the efficiency of the operating force by virtue of their greater pride in their work cannot be denied.

In America, the maddening rush for high capacity and increased production has up to the present time, more or less, crowded out the many beautifying refinements so common to European plants. While the quality of service rendered by our plants is fully equal to that of the European plants, and while our huge central stations may be more impressive, it is a fact that ornamental and architectural features from an artistic standpoint have received little attention.

In Europe, after a machine under construction has satisfied all mechanical and electrical requirements, a greater amount of time and effort is spent in improving its finished appearance than is done in this country. This may have been due to the lower price of labor in Europe; but regardless of the underlying reason, it seems that the ultimate result of such time spent justifies the effort.

By this, however, it must not be inferred that we advocate transforming the power plant into a museum of art, filled with all sorts of dust-collecting, useless ornamentation. This would be the other extreme. Simplicity is of paramount importance and the whole design of the plant and the associated equipment should tend toward that end. But with simplicity can be combined that neat, well-finished arrangement which not only satisfied the eye, but which ultimately promotes greater human efficiency. An attractive border around a switchboard, polished guard rails, nicely painted machinery, a well-balanced color scheme for piping, symmetrically arranged apparatus, artistic as well as efficient lighting fixtures, and, which is most important of all, cleanliness —these, and many others beside, are some of the features to which it would be well worth while to give more attention.

Attention to Details

While the value of expert technical knowledge in power plant design cannot be underestimated, for best results such knowledge must be applied contemporaneously with common sense, practical knowledge. The

designing engineer concerned with a host of highly theoretical considerations is often apt to pass over some of the apparently trivial practical features without giving them sufficient consideration. Such small points as location of valves, accessibility of fittings and piping are often just as important as determining elongation stresses due to thermal expansion, and only a practical operating engineer can adequately recount the atrocities committed in this phase of engineering construction.

In some cases valves are installed in such awkward positions as to play havoc with the operating engineer's composure each time it becomes necessary to operate them. In fact, inaccessible fittings and valves are probably the cause of more profanity in the engine room than any other single condition known.

It is often just as easy to locate a valve so that it may be conveniently operated without danger of burning the hands, or without the necessity of undergoing excruciating contortions, as it is to place it in such a position that only a trained acrobat can manipulate it. Sometimes it is merely a case of turning a valve around, or to raise it or lower it a little, sometimes it is simply a case of allowing a trifle more space between certain fittings. Again, it may be only a matter of providing a suitable reach-rod or the installation of a special fitting; but each case, if correctly dealt with, will save time and temper. Trivial as these things may appear to the designer, they are of great importance to the man who is required to operate them daily, and it is just the correct solution of such small points which, taken collectively, makes for best engineering practice.

It is safe to say that in cases where an operating engineer is in charge of construction, the matter of accessibility and operatability of valves and fittings receives full consideration. He knows too well the annoyance and vexation caused by placing them wherever space allows on a blueprint, and, if nothing else, his human regard for the other fellow who operates them should guide his actions in the matter.

Off Duty

To a flea a mouse must seem a ponderous mass of animal matter—far more ponderous, no doubt, than an elephant seems to us. Yet, to the mouse, the elephant is relatively as large as the mouse itself appears in the eyes of the flea. Is the elephant big? Is the flea small? We may be inclined to reply, yes. Still, in comparison to a very moderate sized microbe, the flea must appear tremendously large. Can we then refer to the flea as being small? Apparently not; considered in this light, the flea is an enormous creature.

It is obvious, therefore, that bigness and smallness are at best only relative terms. There is no such thing as absolute bigness or smallness. An object is small or large only in comparison with some other object and we cannot call anything large or small unless we also indicate our standard of comparison.

Our earth is about 8000 mi. in diameter; the sun, about 1,000,000 mi. The sun then, using the earth as a standard of comparison, is inconceivably big. To show, however, that the principle of relativity of size holds true even here, let us direct our attention to recent developments in the measurement of stellar diameters, by Prof. Michelson of the University of Chicago.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

Together with other scientists, Prof. Michelson has developed an instrument, the "interferometer" as it is called, for measuring the diameters of stars with remarkable precision. The first star to which this new yard stick of Michelson's has been applied is Betelgeuse in the constellation of Orion and the figures expressing the results of this measurement are absolutely astounding.

This star, approximately 150 light years distant, is found to have a diameter of 300,000,000 mi.! Imagine, if you are gifted with a sufficiently flexible imagination, the almost inconceivable mass of a body 27,000,000 times the size of the sun; over 52 trillion times the size of the earth! Is our sun large? Small, do we hear you say? Yes, indeed, incredibly minute.

On the other hand, let us next turn our attention to England and investigate the performance of a new device developed by Prof. R. Whiddington of Leeds University for the measurement of extremely small distances. We have for some time past grown accustomed to the common limit of precision in machine work, i. e. the thousandth of an inch. Most of us, no doubt, have also heard in a general way of the high precision afforded by the so-called interferometer methods developed for use in connection with the manufacture of gages. The latter method has given us precision measurements accurate to one one-millionth of an inch.

Prof. Whiddington's ultra-micrometer now permits measurement to the scarcely creditable precision of one two-hundredth of a millionth of an inch! In comparison with this, our modern micrometer, capable of measuring to a half of a thousandth of an inch, is a crude, clumsy, inaccurate measuring stick. The ultra-micrometer is 100,000 times more accurate.

The new apparatus is based on the fact that if an electric circuit consisting of a parallel-plate condenser and inductance be maintained in oscillation by a thermionic valve, a small change in distance between the plates of the condenser produces a change in the frequency of the oscillations which can be accurately determined.

So sensitive is this device that the deflection caused by the bending of a very substantial table due to the weight of an English penny may clearly be indicated.

With the development of the two methods of measurement described here, we have opened up new possibilities in the realm of science, for accurate measurement is the basis of all scientific achievement. New laws will be discovered, accurate facts will replace former hypotheses, some of our older theories may perhaps be shattered, but in the end the sum total of human knowledge will have been increased and we shall have advanced one step on the never-ending trail of progress because of the efforts of these tireless investigators of nature's secrets.

Weighing Feed Water

ACCURATE weighing of boiler feed water has for many years been recognized as necessary in the economical operation of steam power plants; but only during the last few years, and since the advent of high priced fuel, has its importance been more fully recognized.

The weighing of the fuel alone does not form an intelligent basis upon which performance of the plant can be checked. This is more readily understood when we consider the boiler plant as a manufacturing plant in itself, the coal and water as being the raw material, and steam the product. It is obviously the desire of the

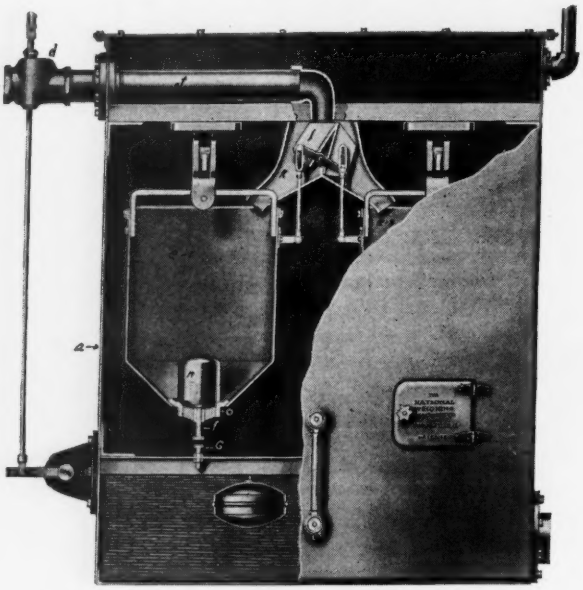


FIG. 1. SIDE VIEW OF FEED-WATER WEIGHER

engineer or plant manager to produce steam as cheaply as possible, and to accomplish this purpose it is essential that all items entering into the production of steam be checked, and as coal and water are so closely co-related in the cost of steam production, the weighing of one without weighing the other is useless.

The real object to be attained in the weighing of coal and water is to provide a check upon the everyday operating efficiency of the boiler and furnace combined, and to furnish accurate knowledge of the cost of producing 1000 lb. of steam. This can be accomplished in no other way than by accurately weighing both the coal and boiler feed water. When the number of each are definitely known, together with the cost of coal per ton delivered, the unit cost of producing 1000 lb. of steam can at once be determined.

Mechanical soot blowers, modern grates, and flue gas analyzers and other such apparatuses are not luxuries but important necessities in the economical operation of a power plant.

But it can readily be seen that though we may have perfect furnace conditions, including tight boiler settings, and the draft properly adjusted to the load the boiler is carrying, and the flue gas analysis may show a high percentage of CO_2, yet we would have no assurance that the heat from the furnace was being absorbed by the water in the boiler, as this can easily be prevented by tubes thickly coated with soot on one side and scale on the other.

The feed water weigher here described is simple and rugged in construction, easily understood, and easy to calibrate to any accuracy desired, and anybody having the necessary knowledge to weigh on platform scales can understand its operation. It is accurate because it operates on hardened steel knife edge bearings, and as each recorded movement denotes true weight, its accuracy is not affected by any variation in temperature. As long as water flows through it, it will operate, and when it is operating you know it is operating right. There is no guess work about it. It will tell you whether your plant is on a paying basis. If you install any economical device it will not only tell you whether it pays, but how much. It will tell you the kind of coal you can burn the most economically in your furnace. It will bring to light the honest efforts of the efficient engineer, and any changes or methods he might make will show the results

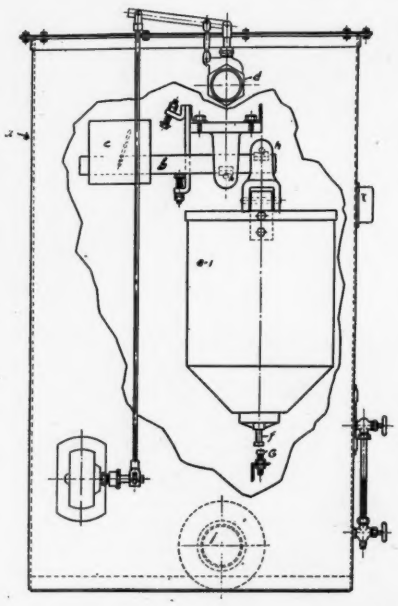


FIG. 2. END VIEW OF FEED-WATER WEIGHER SHOWING METHOD OF SUSPENDING THE WEIGHING BUCKETS

of his efforts. Of course, simply letting the feed water flow through it without any attempt to record details, it would not earn one dollar, and it wouldn't be worth the room it would occupy; but by its intelligent use, the revelation it would make might startle you. You wouldn't think of running a retail business without a cash register, yet a cash register does not add any value to the dollars passing through it, but it does tell you whether your business is operating at a profit or loss, and it is a poor business manager who doesn't know which side of his ledger is the heavier. Your power plant is a business, and a fairly big business at that. Do you know how the business of your plant stands? Is your plant operating at the highest boiler and furnace efficiency? There is no greater incentive to higher personal efficiency than an accurate checking up of indi-

vidual efforts, and with the installation of measuring instruments soon you will note an atmosphere of efficiency around your plant because your plant is on a business basis, and once you get it on a business basis it won't be long until you will have it on a paying basis.

The operation of this feed water weigher involves no new or untried principles, in fact the very simplicity of its design is the reason of its dependable accuracy.

The feed water to be weighed enters through the balanced regulating float valve d (Fig. 1) and passes through the conduit j on through the deflecting valve k into one of the weighing buckets e. As noted from the end view (Fig. 2) each bucket is suspended from one end of a scale beam on a hardened steel knife edge bearing h. The scale beam, being supported from the hanger, is also provided with knife edge bearings. On the outer end of the scale beam is an adjustable counterweight c. As the water continues to flow into the bucket, its weight finally overcomes the counterweight c, causing the bucket to descend, and in doing so it pulls the deflecting valve l over, diverting the water, causing it to flow into the other bucket e-2. It will be noted that in the bottom of the bucket is a valve n, which is called a "buoyant valve" because the upper portion of it is a float, and when seated the static pressure of the water holds it on its seat, but when the bucket descended the stem f which is connected to the valve, stuck the stop pushing the valve off its seat. The buoyancy of the valve now causes it to rise to its uppermost position, and its buoyancy will cause it to remain in this position so long as there is water remaining in the bucket to float it, but when the water has flowed out of the bucket it will drop down on its seat by gravity. When the other bucket fills, its action is the same as the one described, and the operation will continue as long as there is water flowing through the weigher.

There is a continuation of the deflecting valve stem m (Fig. 2) leading to a counter r which records the discharge of each bucket, and also integrates the total amount passing through the weigher.

To calibrate the instrument, move the counterweight to the outer end of the scale beam, then fill the bucket about one-third full of water and push the valve stem f up, causing the valve to ascend. When the valve has seated, a small portion of water it will be noted remained in the bucket, but this amount is constant and will never vary. Next weigh the amount of water the bucket is intended to hold (depending upon the size of weigher) upon scales of known accuracy and pour into the bucket. Now move the counterweight slowly inwardly, just the same as you would move a weight on platform scales, until it just breaks the balance. Calibrate the other bucket the same way, and it will then continue to weigh as calibrated so long as there is water flowing through it.

There are doors provided conveniently located for inspection; and in addition the top is removable, making it easy to calibrate and clean when desired. The outlet can be placed in any desired location, that is on either side, end or on the bottom to meet any installation requirements. A water gage is provided, showing the level of water in the storage, which is designed to hold four bucket discharges. No greater amount is necessary as the float valve is quick in its action and instantly responds to any sudden requirements.

A New Furnace Instrument

THERE ARE few furnaces of any type, especially boiler furnaces, that are not equipped with gages of some description for indicating the various draft pressures. There are many different designs of instruments for this purpose, ranging from the simple U-tube filled with water to the more accurate inclined tube and diaphragm types. There are also various combinations of gages to show both single and differential draft.

The importance of such instruments for the proper control of combustion has been discussed many times by many different engineers until today they are considered just as much a part of the boiler equipment as the steam gage.

The great drawback to a large majority of such instruments is that they are indicating only and give no record of the quantities they measure. As a guide to the firemen, the indicating instrument is all right, but its use is for the primary purpose of saving fuel and

A RECORDING DRAFT GAGE FOR SHOWING BOTH SINGLE AND DIFFERENTIAL DRAFT

the engineer in charge does not know whether proper conditions for the economical use of fuel have been maintained unless all of his time is spent at the furnace watching the indicating gage.

Instruments which will not only be used as indicating instruments but will also give continuous graphic records of the draft pressures maintained are now available. One of recent design shown in the accompanying illustration consists of a cylindrical vessel partly filled with water, in which is placed a bell-shaped float guided centrally on roller bearings.

Attached to the float is a pen rod which passes, by a water seal, through the top of the instrument. The pen is in contact with a 24-hr. rectangular chart 4 in. high and 14 in. long. By using a rectangular chart, the distortion and inaccuracy common to the circular chart is avoided. A dust-proof cover provided with windows encloses the recording drum and pen. The windows are large and so located that the fireman can readily read the pressure indicated by the position of the pen on the chart.

If the instrument is used for recording single draft, only one connection is made, the other being left open to the atmosphere; but if used for differential draft, the two pressures are connected to opposite sides of the float and their difference indicated and recorded on the chart.

The illustration shows the instrument as designed for indicating and recording on the same chart both single and differential draft. The construction is the same as in Fig. 1 except that two chambers are used instead of one. The maximum range of these instruments is 4 in. of water either above or below the pressure of the atmosphere.

This type of instrument, aside from giving a continuous and accurate record of the various draft pressures, has the following advantages. It is made entirely of non-corrosion materials, thus insuring long life. Practically the only friction is fluid friction, so that the instrument is accurate and responds quickly to changes in pressure. Changes in temperature of the water in the instrument do not change the zero point. Accurate leveling is not necessary. Lugs are provided so that the instrument can be mounted on the boiler front or instrument board.

A Combustion Guide for the Fireman

EXCESS air probably wastes more fuel in most power plants than any combination of other avoidable sources of loss. This loss represents in most cases from 10 to 40 per cent of the coal burned. To insure a correct amount of air being used in the combustion of the fuel, some sort of draft indicator is essential to guide the fireman in the control of his dampers.

This apparatus is designed to show the relation between steam flow, draft through the fire and draft through the boiler setting. For ideal conditions, the gages are adjusted to stand at the same height. For efficient conditions at all loads the liquids in the gages will rise and fall together maintaining a constant relation to each other. Pressure differences due to both steam and air flow, vary as the square root of the velocity. The other factors involved, though different, are constant for a given condition and may be compensated for in the instrument by variable adjusting tubes, which, by controlling the areas in the liquid reservoirs and hence the relative moments of the different liquid levels, make alinement possible. The liquid level in the upper tube varies in proportion to the steam flow, those in the lower tubes, in proportion to either quantity of air flow or change in the resistance to flow in either the fire bed or through the boiler tubes. Figure 1 shows a few of the combinations possible and the conditions causing them. Figure 2 is a drawing of the instrument showing the connections that are to be made.

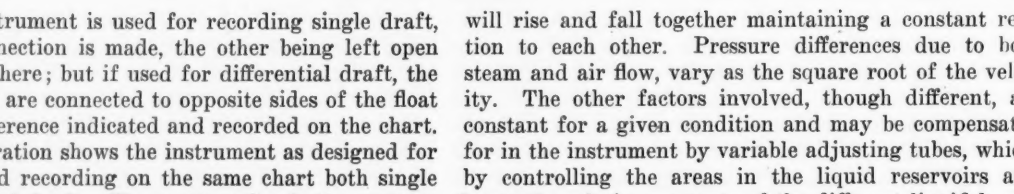

Air supply correct—fire and boiler in good condition.
Excess air—
Fire and boiler in good condition.
Holes in fire permitting air to get through unused—Steam low.
Excessive soot has increased friction through tubes and lowered steam.
Fire too thick or clinkers are interfering with passage of air through firebed.
Correct air supply—fire O. K.
Baffle broken—gases short circuiting.

FIG. 1. VARIOUS CONDITIONS OBTAINING IN THE FURNACE AND THEIR CAUSES. THE TOP LINE IS INDICATIVE OF THE STEAM FLOW, THE MIDDLE LINE SHOWS THE DRAFT LOSS THROUGH THE BOILER TUBES AND THE BOTTOM LINE THAT THROUGH THE FIRE BED

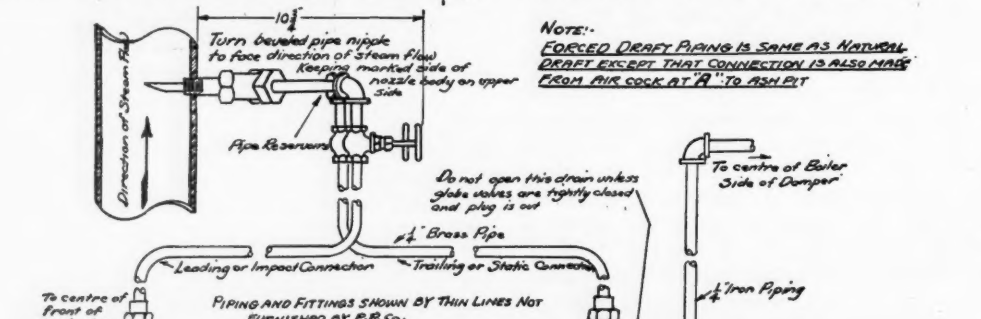

NOTE:-
FORCED DRAFT PIPING IS SAME AS NATURAL DRAFT EXCEPT THAT CONNECTION IS ALSO MADE FROM AIR COCK AT "A" TO ASH PIT
Turn beveled pipe nipple to face direction of Steam Flow keeping marked side of nozzle body on upper side
Direction of Steam Flow
Pipe Reservoirs
Do not open this drain unless globe valves are tightly closed and plug is out
To centre of Boiler Side of Damper
¼" Brass Pipe
Leading or Impact Connection
Trailing or Static Connection
¼" Iron Piping
PIPING AND FITTINGS SHOWN BY THIN LINES NOT FURNISHED BY P.P. Co.
To centre of front of Combustion Chamber
Iron Piping
Equalizing Valve for obtaining initial adjustment on "STEAM"
Vent Hole for initial adjustment of "AIR-DRAFT LOSS ACROSS TUBES"
A
17¼"
B
D
STEAM
AIR - DRAFT LOSS ACROSS TUBES
AIR - DRAFT LOSS THRU FIRE BED
Rod for withdrawing tubes
Nest of Six Brass adjusting tubes
Asbestos Gasket
White-or-mottled slate
French Plate Glass
Gasket with printed instructions
Spirit Level
E
C
Section on B-C
Section on D-E

FIG. 2. DRAFT AND STEAM FLOW INDICATOR SHOWING CONNECTIONS NECESSARY

Washington Letter

WATER POWER PERMITS DEMANDED; THE MERCHANT MARINE. BY A. P. CONNOR

THE FEDERAL Power Commission is becoming a busy center for demands for permits and licenses in the matter of power projects on navigable rivers and in the public lands. It has not as far as known at the present minute issued any permits or licenses, and will not perhaps for a month or so, as there is a lot of investigation to be done in connection with each application before being granted. There appears to be considerable activity on the part of certain power interests to gain control of large projects, and quite a number of interests with headquarters in New York City are asking control of water power projects in Washington and other States.

It is understood that the Commission is trying to act judiciously on the applications before it and in such a manner as to protect the best interests of the country in general. There is one feature which many of the applicants appear to overlook in their plans, and that is the provision of adequate navigable facilities on the rivers they propose to use. In certain cases the provision of suitable dams will make the rivers navigable, but will cost more than the projectors of the project anticipate and they are reluctant to provide for the convenience of industrial centers beyond their dams, and this is a phase which the Federal Power Commission in co-operation with the War Department is endeavoring to prevent. Should the Federal Power Commission extend its assistance effectively, it is believed that the country will have its electrical development considerably extended within the next 10 yr., and many of the difficulties with respect to coal delivery and use overcome; and the railroads provided with a competitor and an assistant that will greatly facilitate and encourage commerce and industry near the river territories of the United States. At the present time there are 121 applications that are officially recognized and announced by the Federal Power Commission and they include projects throughout the States, Washington and New York State appearing to have the greatest number in prospect.

The merchant marine is an item of inestimable value to the country. It enables our business interests to send goods where they will reach the buyer more directly and without passing through foreign brokers who not only take a commission, but also frequently arrange it so that manufacturers who are not of their nation are put at a disadvantage by holding the material in storage, diverting them by roundabout ways to their destination so they will be delayed, and arranging for competitors to come in and take the business, a matter in which their governments use all their official channels to assist in. Another phase of the merchant marine is that all the revenue it takes in goes into the country that owns it. The country that owns the merchant marine has ships built in it, which gives to every industry in that country an opportunity to make and sell goods for it. The advantages of a merchant marine are innumerable and fundamentally control the country's foreign trade, and efforts to discourage it should be carefully investigated, as they are usually the outcome of a deliberate propaganda of foreign interests.

News Notes

THE GREAT WESTERN Contracting Co., Kansas City, Mo., representatives for the Conveyors Corporation of America, Chicago, has changed the name of its organization to the Rawlings Industrial Equipment Co.

THE LOCOMOTIVE SUPERHEATER Co., with general offices 30 Church St., New York City, announce that on Jan. 1, 1921, they opened their own company office at 382-388 Union Arcade Building, Pittsburgh, Pa. John R. LeVally, formerly sales engineer with the Chicago office, has been appointed district manager.

H. J. MOYER, who has jointly represented Yarnall-Waring Co. and Nelson Valve Co. for the past several years in the Chicago territory, has now severed his connection with the latter concern and will henceforth represent the Yarnall-Waring Co. exclusively in that field as district manager. Mr. Moyer's office is now located at 58 West Washington St., Chicago, Ill.

THE CHICAGO PNEUMATIC TOOL Co. announces the appointment, Jan. 1, 1921, of R. F. Eissler, as assistant to the vice-president with headquarters in the company's new office building at 6 East 44th St., New York. W. C. Straub, formerly district manager of the New Orleans branch, has been appointed district manager of the Pittsburgh branch to succeed Mr. Eissler, and Ross Wyeth, formerly attached to the Pittsburgh branch, has been appointed district manager of the New Orleans branch to succeed Mr. Straub.

HAMMOND PURE ICE Co. is planning the construction of a new storage in connection with its artificial ice plant at Hammond, Ind. The structure will be composed of 12-in. brick walls 130 ft. long, 40 ft. wide and 35 ft. high. The cost is estimated at $30,000. This storage is to have a capacity of 3000 tons of ice. The manufacturing capacity of this plant is 65 tons per day, which is inadequate for the increasing population of the city. In addition to the above-mentioned improvements, a water filterer and softener are being installed which will cost in the region of $2500.

U. S. CIVIL SERVICE COMMISSION announces an examination for associate engineer, $2000 to $2800 a year, assistant engineer, $1400 to $1800 a year, to fill vacancies in the Bureau of Standards, Department of Commerce, for duty in Washington, D. C., or elsewhere, at the salaries indicated, and in positions requiring similar qualifications, at these or higher or lower salaries. Appointees at annual compensation of $2500 or less, whose services are satisfactory, may be allowed the increase granted by Congress of $20 a month. On account of the needs of the service, applications will be received until further notice. Applicants will be rated in the following optional subjects, and they should specify in answer to Question 1 of the application form in which of these subjects they desire to qualify: Electrical engineering, mechanical engineering, civil engineering, chemical engineering, ceramic engineering. Applicants must show that they have been graduated with a degree from a college or university of recognized standing, with the completion of at least 118 credit hours. Applicants must not have reached their fiftieth birthday on the date of making oath to the application.

Age limits do not apply to persons entitled to preference because of military or naval service. Apply for Form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.

Book Reviews

HYDRAULIC TURBINES, by R. L. Daugherty; 278 pages, 153 illustrations; third edition, New York, 1920.

Essentially and as stated in the preface of the first edition of this book, the purpose of the text is to give the following: A general idea of water power development and conditions affecting turbine operation, a knowledge of the principal features of construction of modern turbines, an outline of the theory and characteristics of the principal types, commercial constants, means of selection of type and size of turbine, cost of turbines and water power and comparison with cost of steam power. Since the publication of the first edition, however, chapters have been added on turbine governors and on the methods of turbine design.

The latter, which have been inserted in order to meet the demand for information on that subject, are those employed by the best present day designers and are of such character as to avoid the old cut-and-try practice on one hand and a highly theoretical treatment on the other hand. And while that part of the text which is devoted to design will be found of much value to those engaged in such work, it is the belief of the author that both the construction and the operating man can be benefited by a study of this section of the book. Many phases of turbine construction and performance may be best understood with a knowledge of at least some of the elements of design.

Of particular value are the questions and numerical problems following each chapter of text. By means of these, the most important feature presented may be more firmly impressed upon the mind of the student, while the problems illustrate the practical application of the principles presented.

Following a general discussion of water wheels and turbines, types of machines and their settings are taken up in Chapter II. Chapters IV to IX inclusive are devoted to such subjects as the tangential water wheel, the reaction turbine, turbine governors and the general theory of tangential water wheels and reaction turbines. Turbine testing, general laws and constants, turbine characteristics, selection of type turbines and costs of turbines and water powers are some of the subjects discussed in the following five chapters. Design of water wheels of the tangential type and reaction turbines are the features of Chapters XV and XVI, while the last, or Chapter XVII, is devoted to centrifugal pumps.

ELEMENTS OF ENGINEERING THERMODYNAMICS, by J. A. Moyer, J. P. Calderwood and A. A. Potter; 216 pages, 6 by 9 in., 75 illustrations, steam tables and heat-entropy diagram. Cloth. New York, 1920.

A concise but complete treatment of this important branch of engineering. It uses higher mathematics freely to derive equations and is intended as a text-book for students of the subject, an enlargement and extension of an earlier work on the subject.

MODERN WELDING METHODS, by Victor W. Page; 292 pages, 5 by 8 in., 113 illustrations, cloth; 1920.

This book covers welding by oxy-acetylene, thermit and electric processes, giving information useful to factory executives and shopmen on joining metals by welding, soldering and brazing. Apparatus is described, instructions for preparing work and for doing the job are given and cost data for different methods of welding and classes of work. An outline of forge welding is included, also for heat treatment of steel and for tempering. The book will be found of practical help to those having to supervise or to perform welding and other operations of which it treats.

MECHANICAL WORLD YEAR BOOK FOR 1921; 328 pages, 4 by 6 in., cloth bound.

This handbook contains, besides a diary and a classified buyers index in English, French, Spanish and Russian, some useful information on the subjects of steam and the steam engine; condensing plants, turbines; boiler and setting construction; chimneys; gas and oil engines; gas producers; properties of metals; building construction; gear design; screw cutting; machine shop practice; bearings; belting and rope drives; friction and lubrication; hydraulics; steam heating; tables of weights, areas of circles, squares, cubes, square roots, cube roots, four place logarithms and trigonometric functions.

As will be seen, it treats of a deal of material, making it a handy book to have on hand when information is needed.

HANDBOOK OF INDUSTRIAL OIL ENGINEERING, by John Rome Battle; Vol. 1, Oils and Lubrication, 1131 pages, 5 by 7 in.; fully illustrated and indexed, and classified by topics into 11 sections; flexible cloth; Philadelphia, 1920. Second edition.

This work may justly be characterized as monumental. It embodies results of a vast amount of intelligent and purposeful work and contains fundamental data and information on a great variety of subjects with which oil engineering is concerned. Its inclusiveness can best be illustrated by giving the subject heads of the various sections:

Mathematics, Marketing, Mechanical Engineering, Petroleum and its products, Fats and Oils other than Petroleum Products, Testing and Properties of Oils, Lubrication and Friction, Filtering and Reclamation of Lubricating Oils, Oil Storage and Handling, Industrial Practice and Utilization of Lubricating and Industrial Oils, Industrial Oil Specifications. These give but little idea of the detail treatment of the subjects; for instance, under section 10 on Industrial Practice, there are 49 sub sections on various topics ranging from Chains and Cables to Water Wheels and Generators, covering nearly every industrial operation and type of machinery and plant. Much of the latest oil equipment is described and illustrated, also selection and purchase of oil products and equipment to assist in purchasing and using lubricants intelligently. Terms and trade customs of the Oil Industry are explained; pages are arranged for inserting prices, tests and specifications for oils used by the reader.

While the price is somewhat high, the great value of the book justifies it, and the wide field covered makes it of interest and importance to all who have to do with marketing, purchasing and using lubricants.